S 622.25 L3crau 1984 V.2
Comprehensive reclamation of abandoned hard rock mine sites in the urban area of Butte

2.D.093

Appendices A,B, and C

COMPREHENSIVE RECLAMATION OF ABANDONED HARD ROCK MINE SITES IN THE URBAN AREA OF BUTTE AND WALKERVILLE, MONTANA

DEPARTMENT OF STATE LANDS

HYDROMETRICS
CONSULTING SCIENTISTS & ENGINEERS

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Appendix A

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(406) 494-5369 or (406) 723-8905

BUTTE AML PROJECT

Study Prepared

by

Piper & Associates, Inc.

for

HYDROMETRICS

Date: 2/24/84

R. D. Piper
R. D. Piper, P.E., L.S.
President

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- Mt. Con-Steward Area
- Miscellaneous Areas
- Photo Negatives

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INTRODUCTION

Hydrometrics is under contract with the Montana Department of State Lands (DSL) to assess impacts of abandoned mine lands and associated facilities in the Butte area. They, in turn, assigned Piper & Associates, Inc., as sub-contractors, to determine by investigation those disturbed lands, facilities and mines that are a clear threat to public health and safety.

In developing the list of mining related problems with clear threats to health or safety, P & A essentially investigated all disturbed lands and mines in the Butte Urban area. An occasional small prospect shaft or adit opening that may have been camouflaged in the past as the Butte area was developed, and with no record of their location, is not a part of this investigation.

Some hazards exist from past subsidence in the Butte area particularly from ruptured utility mains (natural gas and water) and structural damage. A generalized subsidence map shows the areas where past movement has taken place and may occur again. The present safety hazards and prediction of potential hazards from subsidence are a part of this report.

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Investigation Process

Mine Shaft, Waste Spoil Piles & Debris

The Butte Urban area is divided into five tracts in order to facilitate a better quality for indexing the mine and disturbed lands of concern. These five tracts, Walkerville, Anselmo-Lexington, Mt. Con-Steward, Belmont, and Miscellaneous Mining Areas are outlined on both the aerial photos and the 200-scale surface maps, which are a part of this report.

A photographic record of each mine unit, including the associated waste disposal areas and mine facilities that was investigated, is also a part of this report. Each photograph is indexed to the aerial photo and the 200-scale surface maps.

The safety and health hazards are given a rating of one to five with five being the most severe and each investigated unit is rated according to this procedure.

Numerous small prospect shafts and openings have been filled with waste rock in the past. There is no evidence on the surface of many of these openings although they are located on the 200-scale maps. For those openings, where there is knownledge and evidence that they have been protected by filling with waste material, a notation "filled" has been added to the surface maps.

During the process of investigation 73 mining units in the Butte District were examined and 162 photos were taken. Each~~h~~ unit was assessed and analyzed for a clear threat to public health and safety. Many of the units present future threats to public health and safety as well as causing significant environmental problems.

SAFETY HAZARD RATINGS

The following are forty shafts and two pits that are considered to have a hazard rating of three to five inclusive. Some of the shafts can be made safe by a "back filling" process whereas a capping or plugging process is required on the rest.

Mine Shaft Name	Hazard Rating	Method of Protection
Belmont Area		
Belmont ✓	4	Capping
Otisco (Air)	4	Back filling
Colorado	4	Capping
Hoy	3	Back filling
Hesperus (area)	3	Back filling
Mt. Con - Steward Area		
Parrott (Air)	4	Capping
Original	5	Capping
Mt. Con	4	Capping
Little Mina	4	Back filling
Buffalo	5	Capping
Original #6	4	Back filling
Benham	3	Back filling
Steward	4	Capping
Anselmo - Lexington Area		
Lexington	5	Capping
Anselmo ✓	5	Capping
West Gagnon	3	Capping
Missoula (Ryan)	3	Back filling

Walkerville Area

Rising Star #1	4	Back filling
Rising Star (Lessee)	4	Back filling
Rising Star (Main)	3	Back filling
Goldsmith (Tong)	3	Back filling
Paymaster (Lease)	3	Back filling
Eveline	3	Capping
Venus	3	Back filling
Moose	4	Capping
Moose (Auaria)	3	Back filling
Diamond	5	Capping
351 Raise-Magna Charta	4	Back filling
West Gray Rock	5	Capping
Valdemere	3	Back filling
Belle of Butte	4	Back filling

Miscellaneous Areas

Mary Louise	4	Drill & Cap
Ardsley Butte	3	Back filling
Bonanza	4	Back filling
Anselmo Air	3	Back filling
Travona	5	Capping
Ophir	4	Back filling
Emma	5	Capping
Britania	3	Back filling

Open Pits

Syndicate	4	Partial filling
Alice	5	Partial filling

SHAFT FAILURE

The rock walls of all but two shafts in the Butte area are supported by wooden rectangular frames which in turn are supported by wooden posts usually five feet apart. Only the Kelley #1 and Kelley #2 are supported with concrete.

Wooden sets in shafts deteriorate from rot, subsequently failing and allowing the rock walls to spall or collapse. If the shaft is partially filled with water, that portion under water will usualy not rot due primarily to the lack of oxygen in the "dead water". Therefore shaft failures are most likely to appear in any shaft above the water level.

The rock walls of a shaft will usually cave beyond the actual confines of the opening and assume a funnel shape from the point of failure to the surface with the slope of the walls being between 60° and 70° from the horizontal. A complete failure of one set of shaft timber allows the sets above that point to loosen and fail releasing all support to the rock walls of the opening from the failure point to the surface.

An abrupt failure will cause the timber sets to collapse and jam at the point of failure forming a bridge that catches the pieces of rock as the shaft walls deteriorate. The open portion of a deep shaft below such a stoppage is a liability and will cause futher failure and coning to the surface.

As water rises in the underground mines the water level will assume a position at a point about 100 feet to 200 feet below and roughly parallel to the contours of the surface. Anaconda has estimated that the water level will be reached in about nine years at which time all the major shafts will be full to about 100 feet to 200 feet below the surface.

The horizontal dimensions of the Butte shafts differ considerably, but the average size of the rock opening in the major shafts is about 25 feet by 9 feet with the smaller supply and air shafts being about 17 feet by 8 feet. A shaft failure at a point 100 feet below the surface will produce an opening on the surface some 35 to 60 feet outside the original shaft size. Therefore an elliptical cone produced by a shaft failure 100 feet below surface can be about 150 feet x 125 feet on the surface.

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ALTERNATE SHAFT PROTECTION PROCEDURES

(Large Deep Shafts)

There are fourteen major shafts, all owned by the Anaconda Minerals Co., that fall outside of Anaconda's Mining Permit Area. Of these, four are greater than 4000 feet in depth, eight between 2000 feet and 4000 feet, one 1800 feet, and one 700 feet.

Three methods of protecting the public from surface openings created by shaft failures are reviewed. Approximate costs of a shaft with an opening 25 feet by 9 feet and 3000 feet deep is used as an example.

Methods:

1. Fill the shaft with waste rock or tailings
2. Concrete, 12 inches thick, reenforced, 100 feet by 100 feet cover over shaft
3. Rails, 120 lbs. per 3 feet, spaced 9 inches apart laid in two directions, 66 feet by 66 feet, decked with either 3/16" steel or planking as a cover over the shaft
4. Cone method using steel and concrete requires that a cone be constructed of steel, fit into a shaft and filled with concrete

1. Fill material must be small enough to guard against "hang-up" and enough water added to keep it moving downward.

Cost estimate:

given: 4 compartment shaft, rock opening 25 feet by 9 feet, 3000 feet deep

25 x 9 less timber = 179 cu. ft. per foot of shaft
= 6.63 cu. yds. per ft. of shaft

3000 x 6.63 = 19890 cu. yds. to fill the shaft

@ $4.80 per cu. yd. = $95,472

2. 12" concrete reenforced pad over shaft, 100 ft. by 100 ft.

100' x 100' x 1' = 10,000 cu. ft.
= 370 cu. yds.

Labor, 4 men, 10 days @ $100/day.....	$4,000
Materials (forming & decking)........	$10,000
Stripping & Clearing.................	$1,000
370 cu. yds. of concrete @ $60/cy....	$22,200
Sub Total..................	$37,200
15% supervision & 10% profit.........	$9,300
TOTAL......................	$46,500

3. Rails laid in two directions, 66 ft. by 66 ft. welded together

120 lb. used rail - @ 265/ton
Rail wt. (120 lb.) actual 132 lbs./3 feet
1452 lbs. per 33 foot rail
150 rails in each direction
150 x 2 = 300 rails
300 x 1452 = 435,600 lbs. or 217.8 tons

217.8 x $265/ton (used rail).........	$57,717
Labor, 4 men, 10 days @ $100/day.....	$4,000
Crane - 10 days @ $400/day...........	$4,000
Decking $\frac{1}{4}$" plate, 21 tons @ $300/ton.	$6,300
Sub Total..................	$72,017
15% supervision & 10% profit.........	$18,004
TOTAL......................	$90,021

Goldsmith (Tong)	drill (two shafts)
Paymaster (Lease)	drill
Venus	cut off surface
Moose (Auria)	cut off surface
351 Raise(Magna Charta)	open - remove cover
Valdemere	open - no covers
Ardsley Butte	drill
Bonanza	open - remove cover
Anselmo (Air)	open - remove concrete cover
Ophir	open - remove cover
Britania	cut off surface

ACKNOWLEDGMENTS

The writer of this report graciously acknowledges the co-operation and support of the following people:

Anaconda Minerals Co.
    Jim Windorski, Manager - Health Safety and Environment - Butte Operations
    Alan Dahlstrand, Planning Engineer - Butte Operations
    George Burns, Geologist - Butte Operations
    Ray Bailey, Safety Engineer - Butte Operations

OCCUSAFE Consultants
    David Kneebone - President
    Hugh Graham - Engineer

Hubert Lorenz - Retired Mining Engineer - Anaconda Minerals Co.

4. Cone method using steel and concrete

The cone method although ideal for small shallow shafts cannot be adapted to large shafts because the cost is entirely prohibitive. The volume of a cone, 100 feet in diameter at 60° side slopes, compares to a 100 ft. x 100 ft. pad, contains 12,605 cubic yards. A cone with a diameter of 14.5 feet, which size fits the average major shaft, contains only 307 cubic yards but would not give protection from shaft failure 100 feet or more below the surface. Also, to place a 60° cone with a radius larger than one-half of a shaft requires that considerable rock must be excavated around the shaft.

Cost estimate:

12,605 cu. yds. of concrete @ $60/cy..$756,300
No further estimate for manpower or supplies is warranted

It is recommended that alternate number two, the 12-inch concrete pad 100 ft. x 100 ft. be considered as a solution for the public protection from caving to surface in the major shafts in the Butte District. The reenforced slab is of such size will not subside into the shaft or break up if the shaft timber fails some distance below the surface.

SHAFT FAILURE PROTECTION PROCEDURES

(Small Shallow Shafts)

Shafts, small in cross-section are likely to cave laterally and choke off any further caving more so than shafts with large cross-sections, although some small shafts may have bulkheads on or near the surface that might fail creating hazardous subsidence. Depending upon each individual situation some of the smaller shafts require testing by drilling to determine the condition of the shafts 30 or 40 feet below the surface. An open section of the shaft determined by drilling could indicate future caving and hazardous surface subsidence. Cutting-off the surface over the shaft with a bulldozer can be substituted for drilling for the determination of sub-surface condition of small shafts.

FIELD INSPECTIONS

All inspections are confirmed by photos that are included in this report. Along with each photo is a discussion on the health and safety hazard for each of the units inspected.

In order to facilitate the map location of the unit photo, each is individually numbered and indexed to both the 200-scale surface plan maps and the aerial maps. The negatives of the photos are indexed according to the film roll on which each photo was taken. To further facilitate the indexing the Butte District is divided into five areas, Walkerville, Belmont, Anselmo-Lexington, Mt. Con-Steward, and Miscellaneous Areas. The photos and description of each unit are divided according to the five areas.

Health and safety hazards are ranked according to factors from 0 to 5 in which 5 is the greatest hazard. Reasons for the ranking are described on each plate on which the photos are attached.

AML PROJECT

Map Index (200-scale maps)

Butte District

	U - 23	U - 27	
	Q - 23	Q - 27	
M - 19	M - 23	M - 27	
I - 19	I - 23	I - 27	I - 31
E - 19	E - 23	E - 27	
A - 19	A - 23		
	Ws - 23		
Ss - 19	Ss - 23		

Not to scale

Map size 16" x 22"

N

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OWNERSHIP
Mining Units in Metropolitan Butte

According to the property index maps kept by the Anaconda Minerals Co., they own both the immediate surface and the minerals on all except two of the units listed in this report.

The exceptions are:

1. Anaconda owns the mineral but does not own the surface of Lot 50, Lizzie Lode, on East Park Street. The Hickey shaft is located on this lot.

2. Anaconda does not own the surface or mineral of the Ardsley Butte Mine. According to a title search done in 1981 the property is controlled by:
   ½ interest by Grant Deed - Winston F. Wright, of Reno, Nevada
   ½ interest by Lease & Option to purchase - Winston F. Wright of Reno, Nevada
   The Option and Grant Deed were given by:
   W. D. Murray & Lula Ann Murray - 1/16 ownership
   Vivian McNeece - 1/16 ownership
   L. G. Tomich - 7/8 ownership
   There is no record that the option was exercised but it could be traced by further abstracting.

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BACK-FILLING SHAFTS - Method of Testing

The recommended method of testing small shafts that require back-filling only, is listed by each unit. The following two methods are considered:

1. drilling sloped hole into the shaft to a point 30 or 40 feet below the surface
   a. if the shaft is open the upper section must be removed in order to back fill
   b. if the shaft is closed likely no hazardous subsidence will appear, although slumping may continue on surface
2. cut off the surface portion of the shaft with either a back-hoe or dozer to expose the condition of the opening

The following shafts are recommended for back-fill:

Otisco (Air)	drill
Hoy	cut off the surface
Hesperus	drill (two shafts)
Little Mina	drill
Original #6	open - no test work needed
Benham	cut off the surface
Missoula (Ryan)	open - remove concrete cover
Missoula #2	cut off surface
Rising Star #1	cut off surface
Rising Star (Lessee)	cut off surface
Rising Star (Main)	cut off surface

ANSELMO-LEXINGTON AREA

The Anselmo-Lexington area encompasses all that portion of Metropolitan Butte and Walkerville west of Montana Street and east of Excelsior Street bounded on the south by the Anselmo shaft and on the north by the Lexington shaft. All waste disposal piles, mine openings, and mining units were examined for health and safety hazards.

Both the Anselmo and Lexington shafts although fenced are considered to be the most hazardous in the area. The fences surrounding both units show evidence of numerous entrances without particular difficulty. The Lexington shaft has been blocked off with a wooden bulkhead a few feet below the surface and the Anselmo shaft has been blocked off with a wooden bulkhead capped with concrete. In both instances the bulkheads are eventually subject to failure. At the Anselmo an uncovered open manway approximately fifty feet south of the main shaft leads down and across to the shaft. Evidences of unauthorized entrance to the manway was noted.

The Syndicate Pit is the next most hazardous unit in this area. The steep walls, subject to caving and the easy entrance into the pit make it very dangerous, particularly due to its location in a heavily populated area.

The West Gagnon and Missoula Ryan present hazardous safety conditions, although somewhat less than the other three.

BUTTE AML PROJECT

AREA: Anselmo - Lexington

VIEW: Looking Southeasterly

PHOTO NEGATIVE INDEX: G10-5

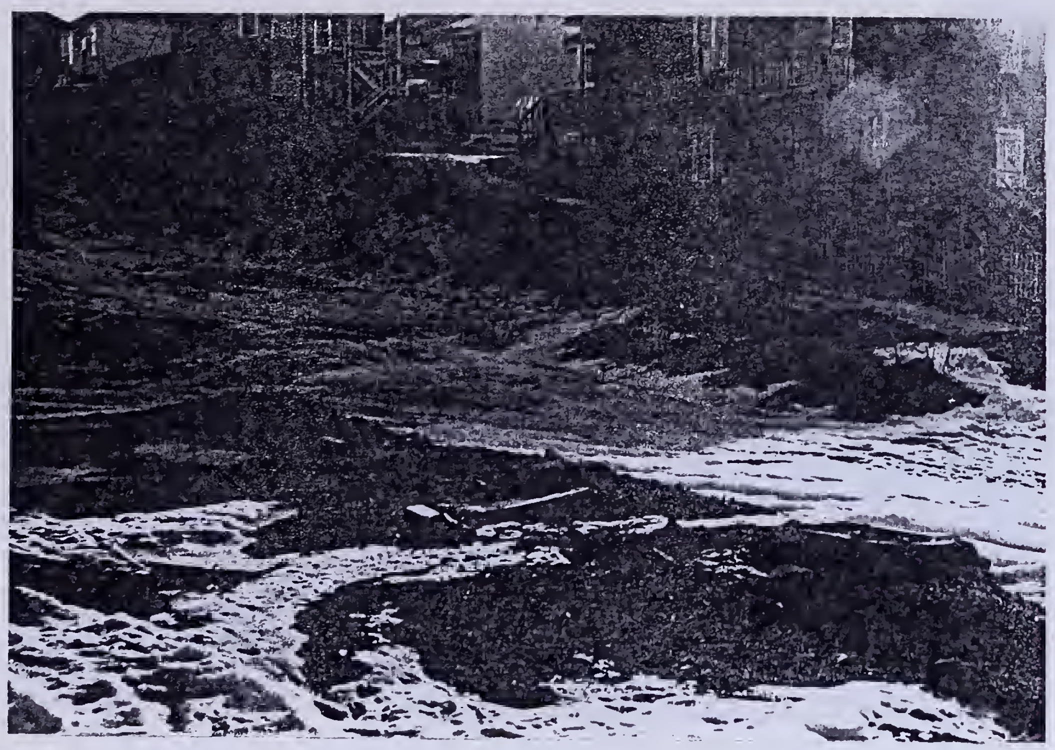
MAP INDEX: M-23-120

MINE: West Gagnon

SUBJECT: Shaft Location

AERIAL PHOTO INDEX: P6-120

PAGE 1 OF 2



SAFETY HAZARD: A concrete reenforced bulkhead with hitches into the walls of the shaft is located several sets below the surface. The bulkhead will likely subside a considerable amount when the timbers eventually rot below the concrete causing the surface over the shaft to move. The shaft is 2800 feet deep and is located adjacent to residences in a heavily populated area.

HEALTH HAZARD:

HEALTH HAZARD FACTOR:

SAFETY HAZARD FACTOR: 3

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Anselmo - Lexington

VIEW: Looking Northerly

PHOTO NEGATIVE INDEX: G10-3

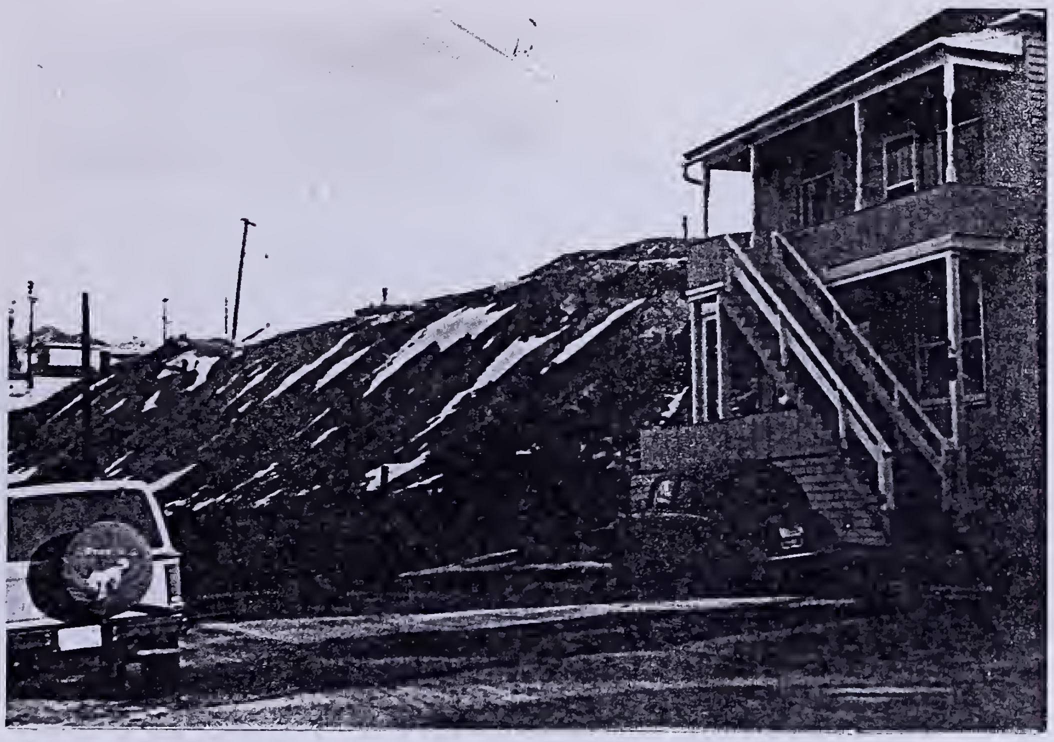
MAP INDEX: M-23-121A

MINE: West Gagnon

SUBJECT: Waste Dump

AERIAL PHOTO INDEX: P6-121A

PAGE 2 OF 2



SAFETY HAZARD: See page 1

HEALTH HAZARD: The waste dump is eroding and the debris is collecting on Jackson Street causing a health hazard from the acid dust.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 3

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Anselmo - Lexington

VIEW: Looking Southeasterly

PHOTO NEGATIVE INDEX: G10-15

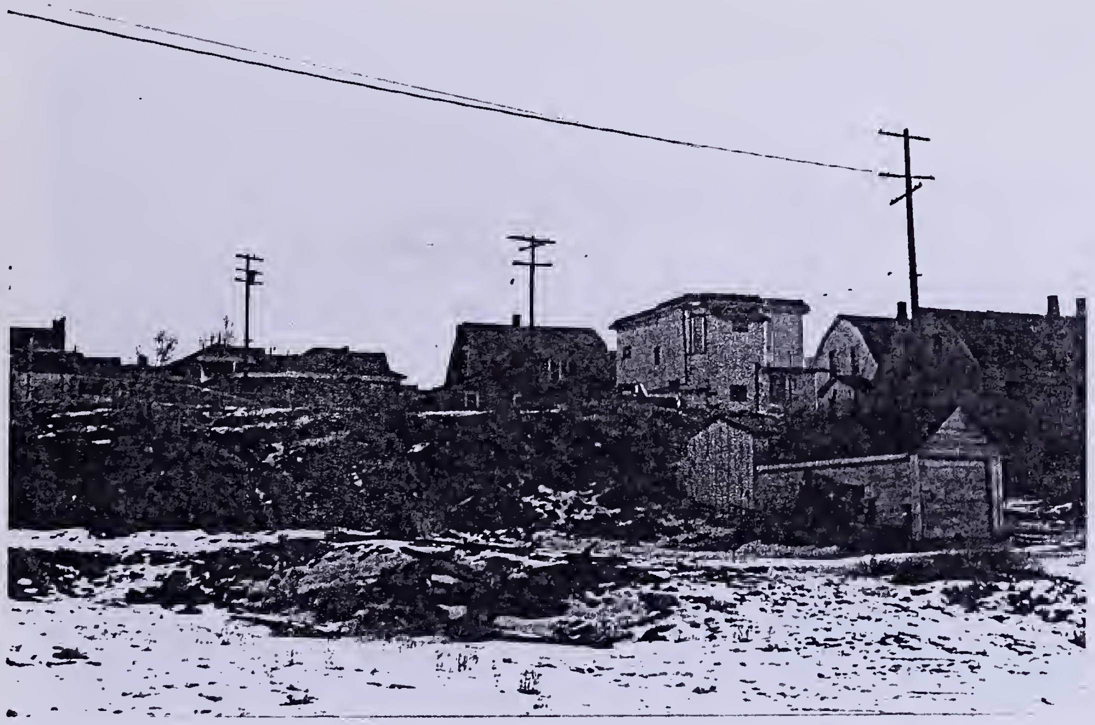
MAP INDEX: M-23-121

MINE: Silver King

SUBJECT: Waste Dump

AERIAL PHOTO INDEX: P6-121

PAGE 1 OF 1



SAFETY HAZARD: The Silver King mine area consists of several small shafts, the Silver King, Sutton, Plymouth and Chapman, which have all been filled during past years. Shallow workings from these shafts have opened to the surface in several places along Quartz and Crescent Streets and have been filled over past years. Some small openings to the surface can be expected in the future but due to very shallow workings no real safety hazard may appear.

HEALTH HAZARD: Children continually dig holes in the waste dump breaking the oxidized crust and causing a condition conducive to blowing dust which can be a health hazard.

HEALTH HAZARD FACTOR: 1

SAFETY HAZARD FACTOR: 2

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Anselmo - Lexington

VIEW: Looking Northwesterly

PHOTO NEGATIVE INDEX: G10-9

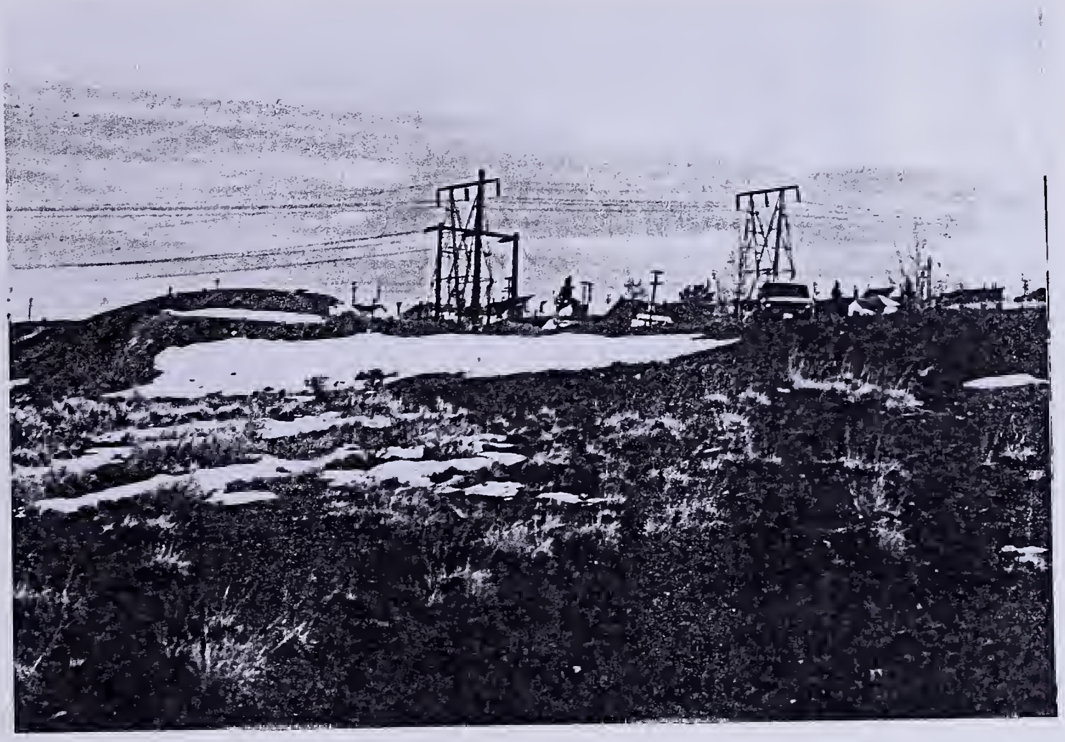
MAP INDEX: M-23-119

MINE: Moscow

SUBJECT: Waste dump

AERIAL PHOTO INDEX: P6-119

PAGE 1 OF 1



HEALTH HAZARD: Some dust can be blown from the dump which is of such acid nature that no vegetation grows.

SAFETY HAZARD: The shaft has been filled many years in the past and there is no evidence of subsidence on the surface.

HEALTH HAZARD FACTOR: 1

SAFETY HAZARD FACTOR: 0

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Anselmo - Lexington

VIEW: Looking Southerly

PHOTO NEGATIVE INDEX: G14-12

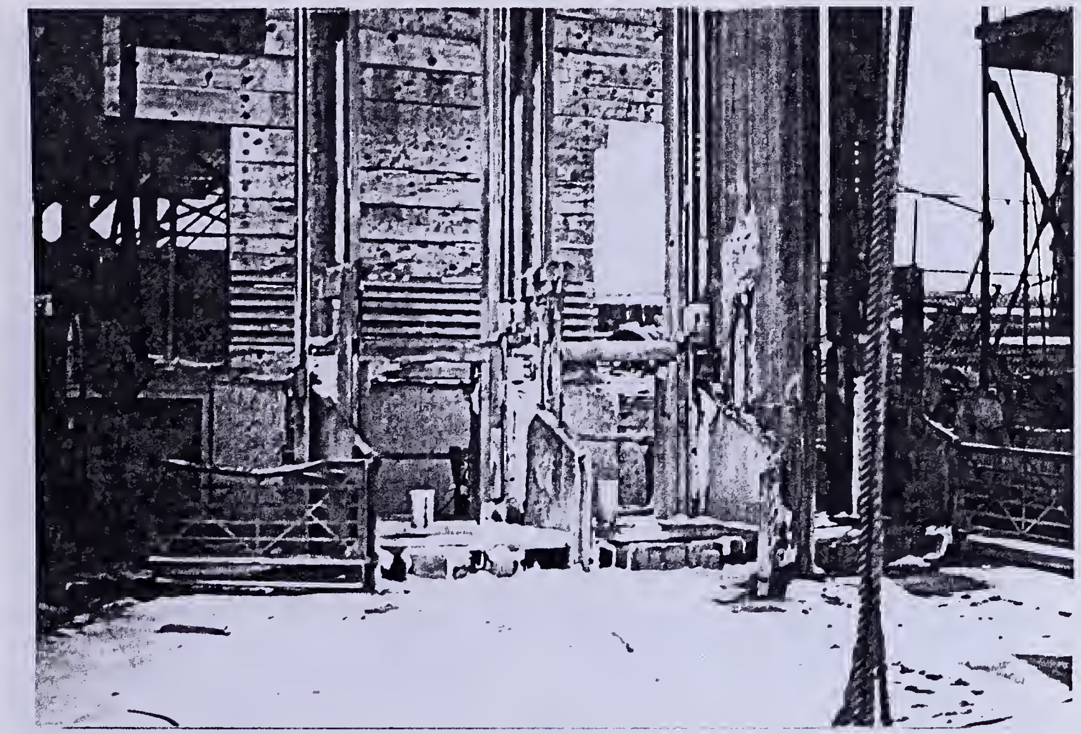
MAP INDEX: M-23-114

MINE: Anselmo

SUBJECT: Shaft

AERIAL PHOTO INDEX: P6-114

PAGE 1 OF 6



HEALTH HAZARD: "Bad air" forced up the shaft as the water rises underground is a hazard to any person who happens to be near the shaft.

SAFETY HAZARD: The shaft, 4500 feet deep, has a concrete bulkhead supported by a wooden frame on the tunnel level about 40 feet below the surface. The man cages are are resting on 8" stringers over two compartments on the surface with the other two compartments covered with three-inch lagging spiked down. The wood support for the concrete bulkhead will rot and the bulkhead will eventually fail, probably causing the surface to cave creating a very serious hazard.

HEALTH HAZARD FACTOR: 3

SAFETY HAZARD FACTOR: 5

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Anselmo - Lexington

VIEW: Looking Northerly

PHOTO NEGATIVE INDEX: G10-11

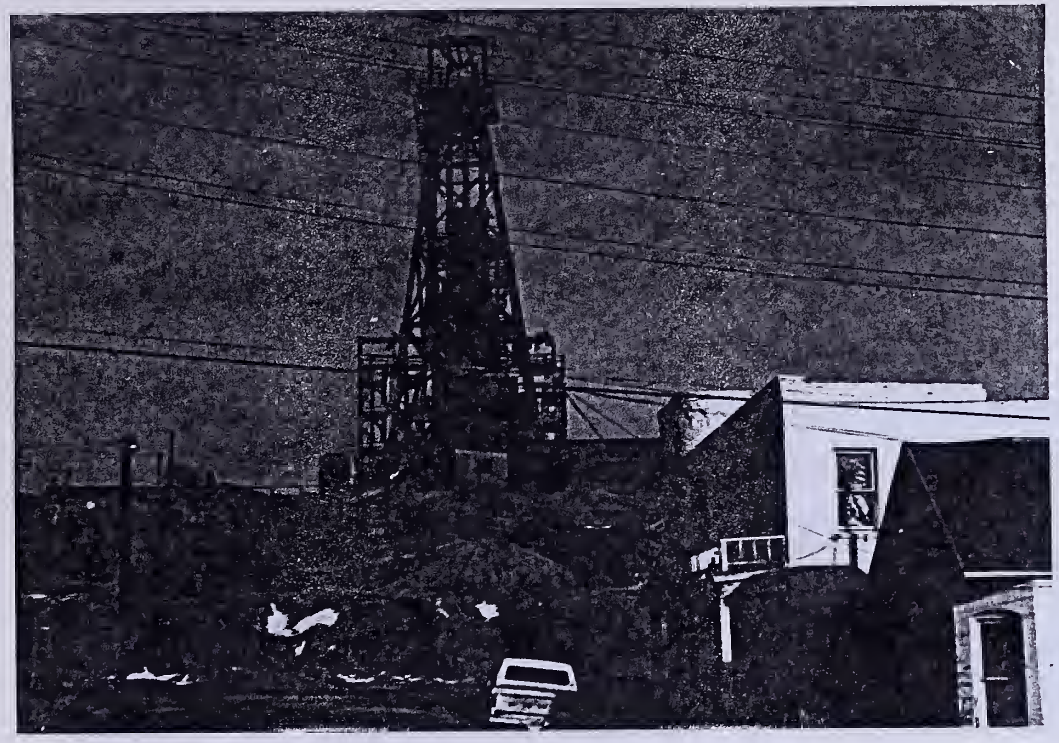
MAP INDEX: M-23-115

MINE: Anselmo

SUBJECT: Headframe & Shaft

AERIAL PHOTO INDEX: P6-115

PAGE 2 OF 6



SAFETY HAZARD: The shaft is located in a heavily populated area. The photo shows the nearness of apartment buildings to the Anselmo shaft.

HEALTH HAZARD: Dust, very acid, is carried by wind to the surrounding populated area creating a health hazard. Erosion from the waste dump also accumulates on the street creating a dust condition.

HEALTH HAZARD FACTOR: 3

SAFETY HAZARD FACTOR: 5

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Anselmo - Lexington

VIEW: Looking Northwesterly

PHOTO NEGATIVE INDEX: G10-10

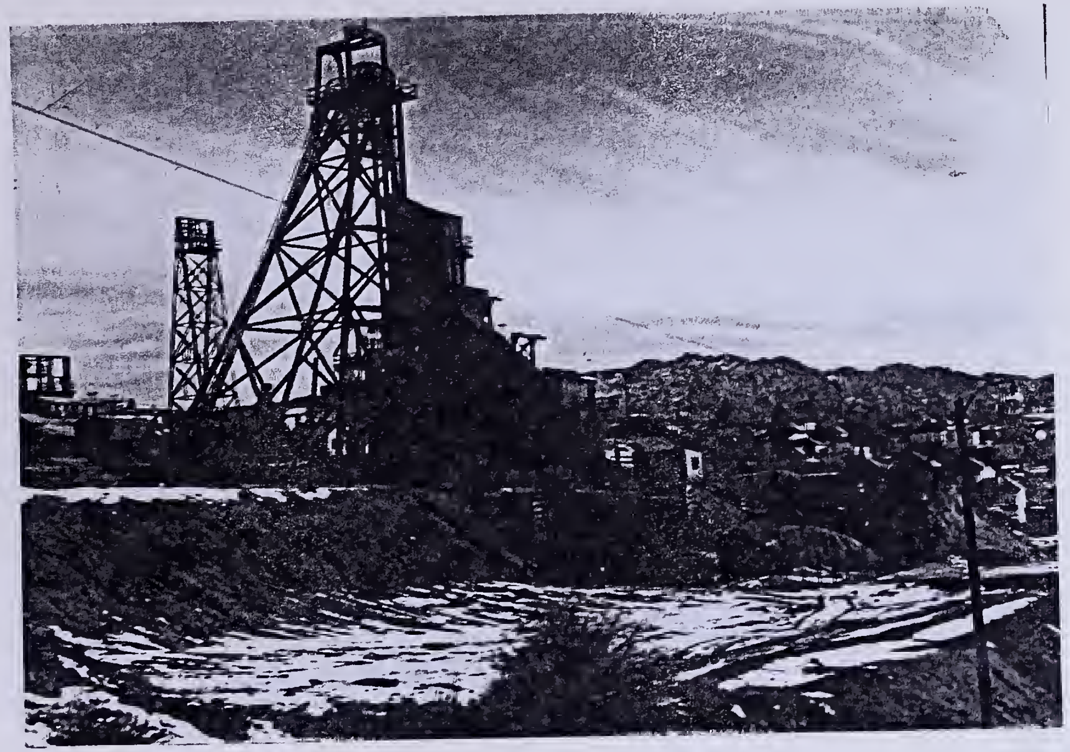
MAP INDEX: M-23-116

MINE: Anselmo

SUBJECT: Headframe & Shaft

AERIAL PHOTO INDEX: P6-116

PAGE 3 OF 6



HEALTH HAZARD: See page 2

SAFETY HAZARD: See page 2

HEALTH HAZARD FACTOR: 3

SAFETY HAZARD FACTOR: 5

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Anselmo - Lexington

VIEW: Looking Northerly

PHOTO NEGATIVE INDEX: G10-12

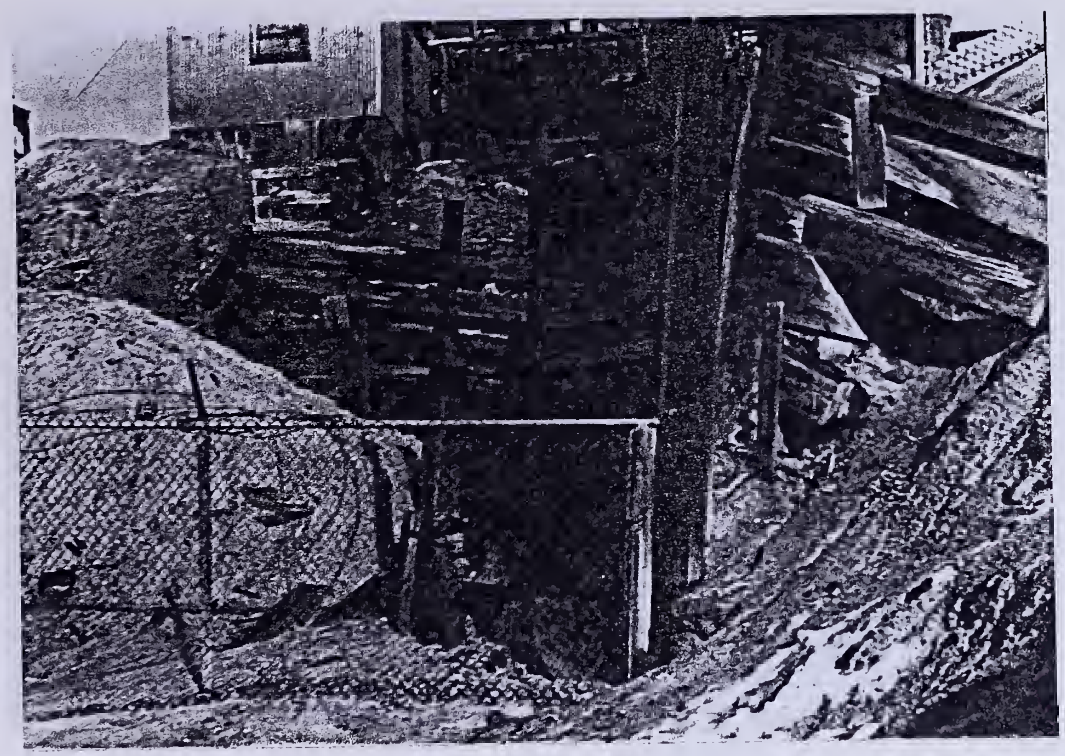
MAP INDEX: M-23-117

MINE: Anselmo

SUBJECT: South Fence

AERIAL PHOTO INDEX: P6-117

PAGE 4 OF 6



HEALTH HAZARD: Dust and sediment eroded from the waste dump is a source of a health hazard.

SAFETY HAZARD: The top wires of the fence have been cut to make easy access to the Anselmo yard at a point 70 feet from Caledonia Street. There is considerable evidence of children having entered the yard at this point. The crib work is vulnerable to fire by vandals. The shaft area is not secure from the public.

Considerable safety hazards exist in the shaft area, such as, the crib work which may fail at any time, the headframe which is being climbed by persons and children entering the yard and the shaft itself per page 1 of this group.

HEALTH HAZARD FACTOR: 3

SAFETY HAZARD FACTOR: 4

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Anselmo - Lexington

VIEW: Looking Northwesterly

PHOTO NEGATIVE INDEX: G10-13

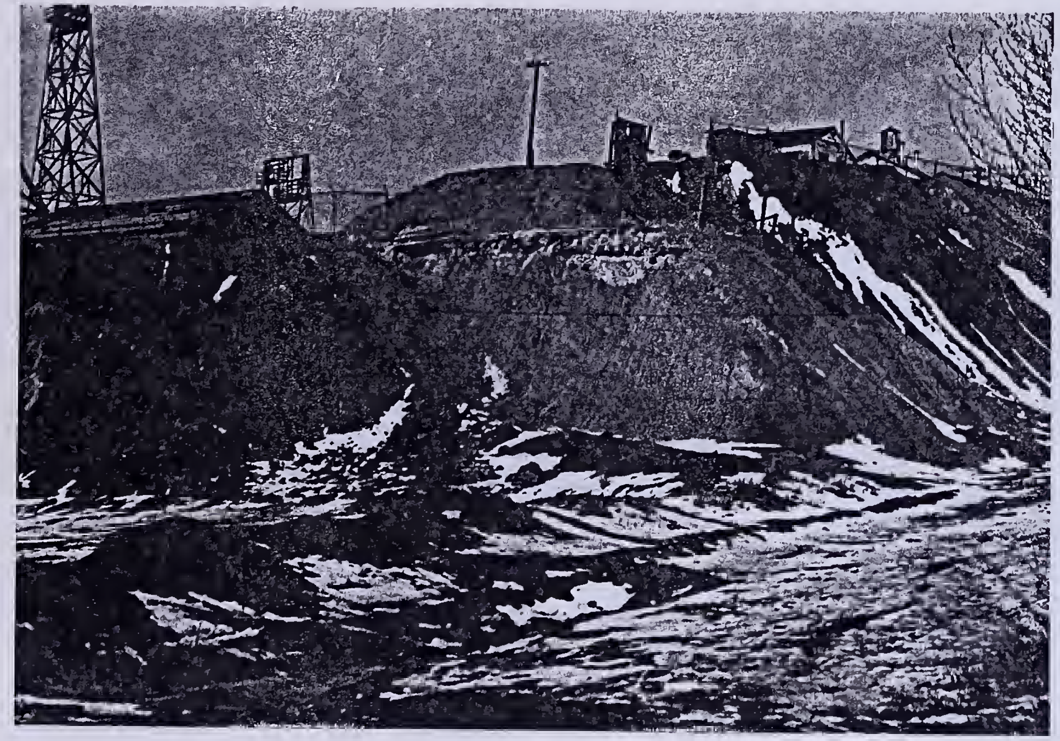
MAP INDEX: M-23-118

MINE: Anselmo

SUBJECT: South West Fence

AERIAL PHOTO INDEX: P6-118

PAGE 5 OF 6



SAFETY HAZARD: Some safety hazards exist from the old timber and pieces of metal protruding from the waste dump.

HEALTH HAZARD: Same as pages 2 and 4

HEALTH HAZARD FACTOR: 3

SAFETY HAZARD FACTOR: 2

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Anselmo - Lexington

VIEW: Looking Southeasterly

PHOTO NEGATIVE INDEX: G17-8a

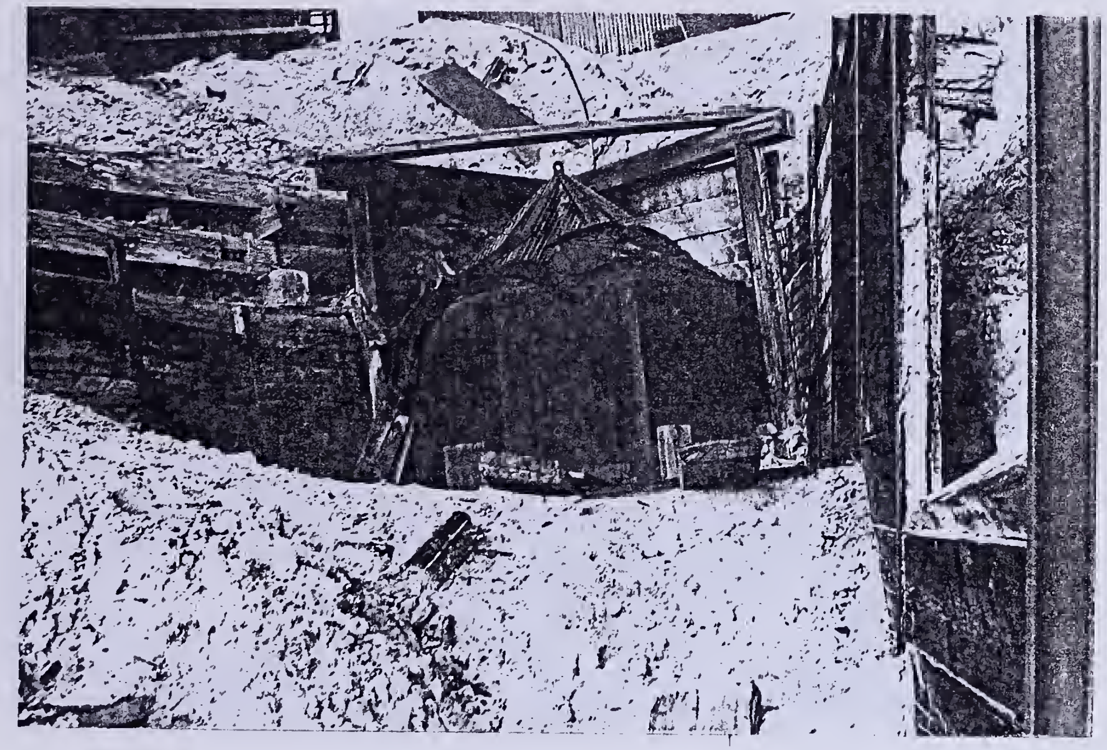
MAP INDEX: M-23-158

MINE: Anselmo

SUBJECT: Marquis Shaft

AERIAL PHOTO INDEX: Pb-158

PAGE 6 OF 6



SAFETY HAZARD: The marquis shaft has an iron grill on top. The shaft is open under the grill. The shaft walls will eventually fail and the ground will chimney to the surface. The area is is vulnerable to the public. There is evidence of people's tracks around the the shaft. A manway with ladders leading down is being used.

HEALTH HAZARD: N/A

HEALTH HAZARD FACTOR:

SAFETY HAZARD FACTOR: 4

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Anselmo - Lexington

VIEW:

PHOTO NEGATIVE INDEX: G16- 6

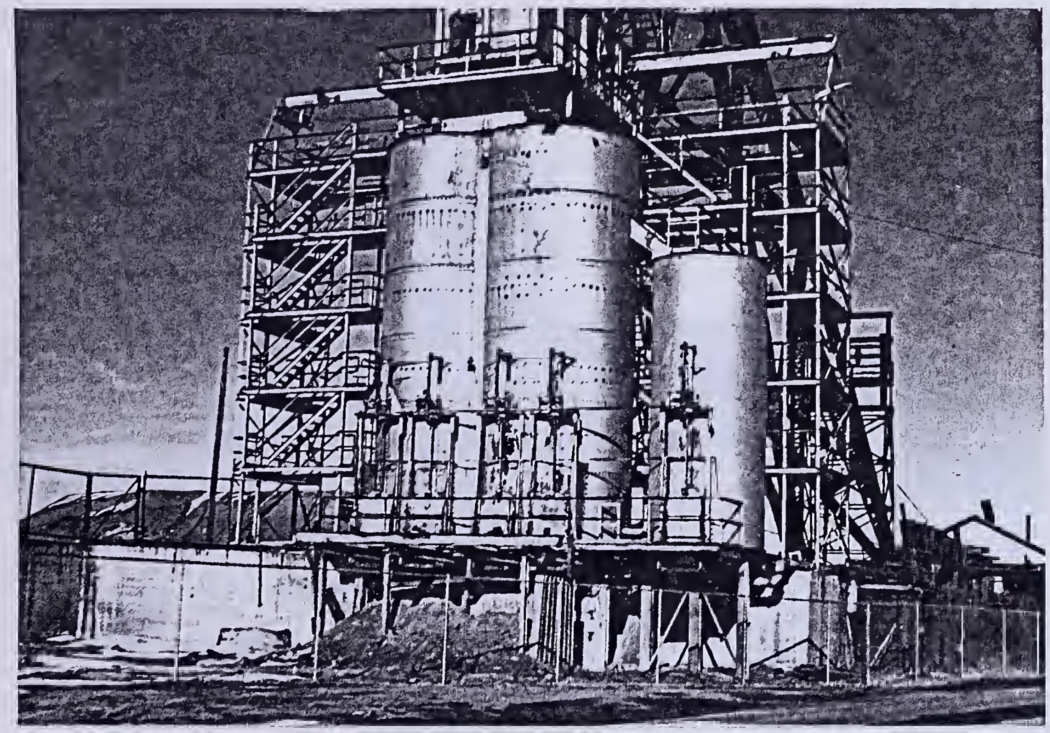
MAP INDEX: Q-27-110

MINE: Lexington

SUBJECT: Headframe

AERIAL PHOTO INDEX: P5-110

PAGE 1 OF 5



SAFETY HAZARD: The Lexington shaft is 3200 feet deep and is adjacent to Main Street and a heavily populated area of Walkerville. The shaft contains a wooden bulkhead a few feet below the surface upon which has been piled waste rock (see page 2). The bulkhead will eventually fail and the surface area will be exposed to an open shaft. The shaft and headframe are easily accessible through holes in the board fence. Children as well as adults are known to have climbed the headframe.

HEALTH HAZARD: "Bad air" will rise in the shaft as the underground water advances up the shaft.

HEALTH HAZARD FACTOR: 3

SAFETY HAZARD FACTOR: 5

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Anselmo - Lexington

VIEW: Looking Southerly

PHOTO NEGATIVE INDEX: G16-7

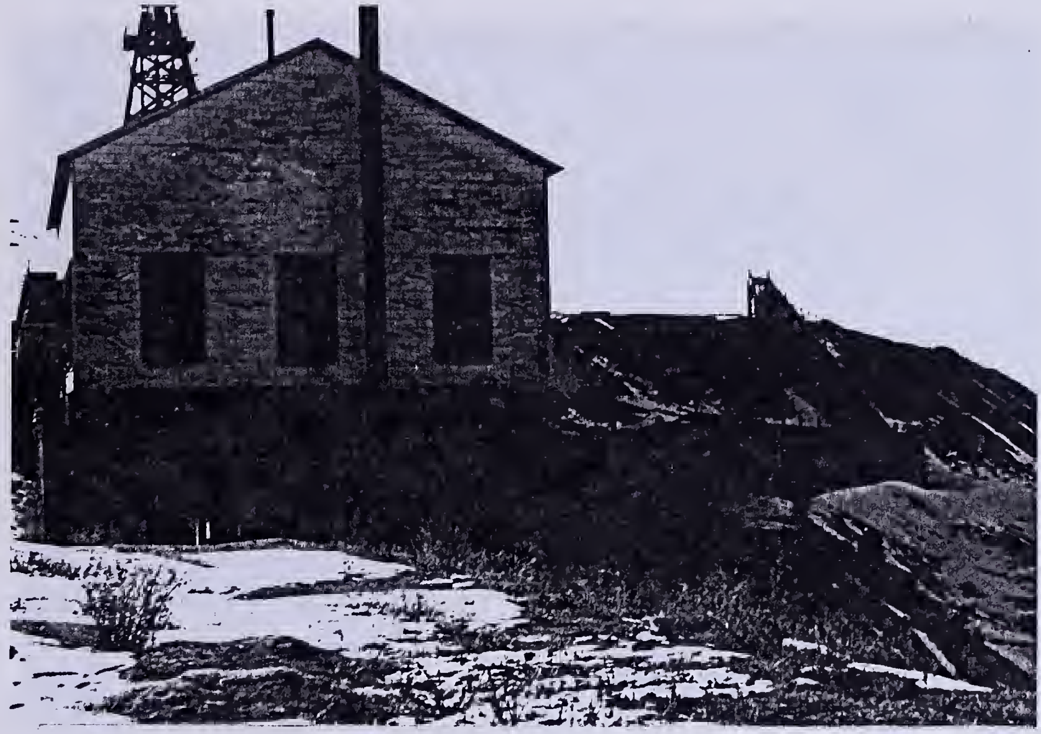
MAP INDEX: Q-27-111

MINE: Lexington

SUBJECT: Hoist house & North Fence

AERIAL PHOTO INDEX: P5-111

PAGE 2 OF 5



SAFETY HAZARD: The photo shows the board fence around the north side of the Lexington yard. Several holes and missing boards make for easy access to the yard.

Shaft - see page 1

HEALTH HAZARD: N/A

HEALTH HAZARD FACTOR:

SAFETY HAZARD FACTOR: 5

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Anselmo - Lexington

VIEW: Looking Northerly

PHOTO NEGATIVE INDEX: G16-4

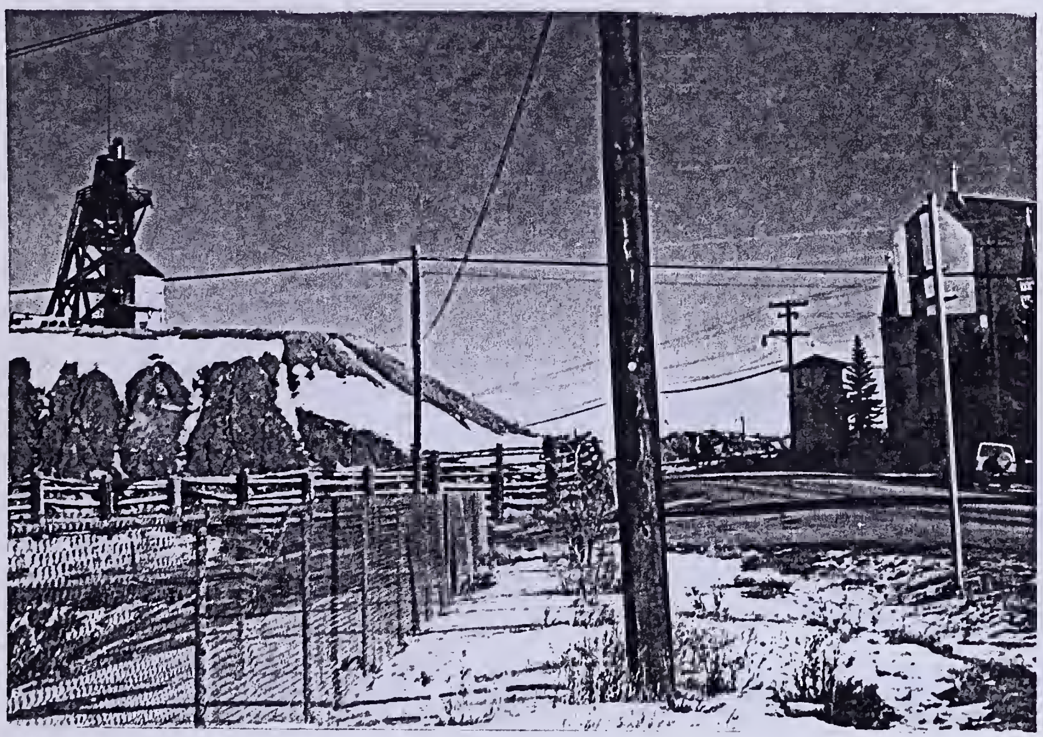
MAP INDEX: Q-27-112

MINE: Lexington

SUBJECT: Waste dump & Headframe

AERIAL PHOTO INDEX: P5-112

PAGE 3 OF 5



HEALTH HAZARD: The waste dump is eroding and the water is carrying sand to Main Street. Dust from the eroded material is a health hazard to the public. Note: St. Lawrence church across Main Street from the Lexington waste dump and yard.

SAFETY HAZARD: Pole barrier on the south side of the Lexington yard and against the waste dump serves as a fence. The pole crib is easily scaled and actually gives very little protection to the yard.

Shaft - see page 1

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 5

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Anselmo - Lexington

VIEW:

PHOTO NEGATIVE INDEX: G14 - 11

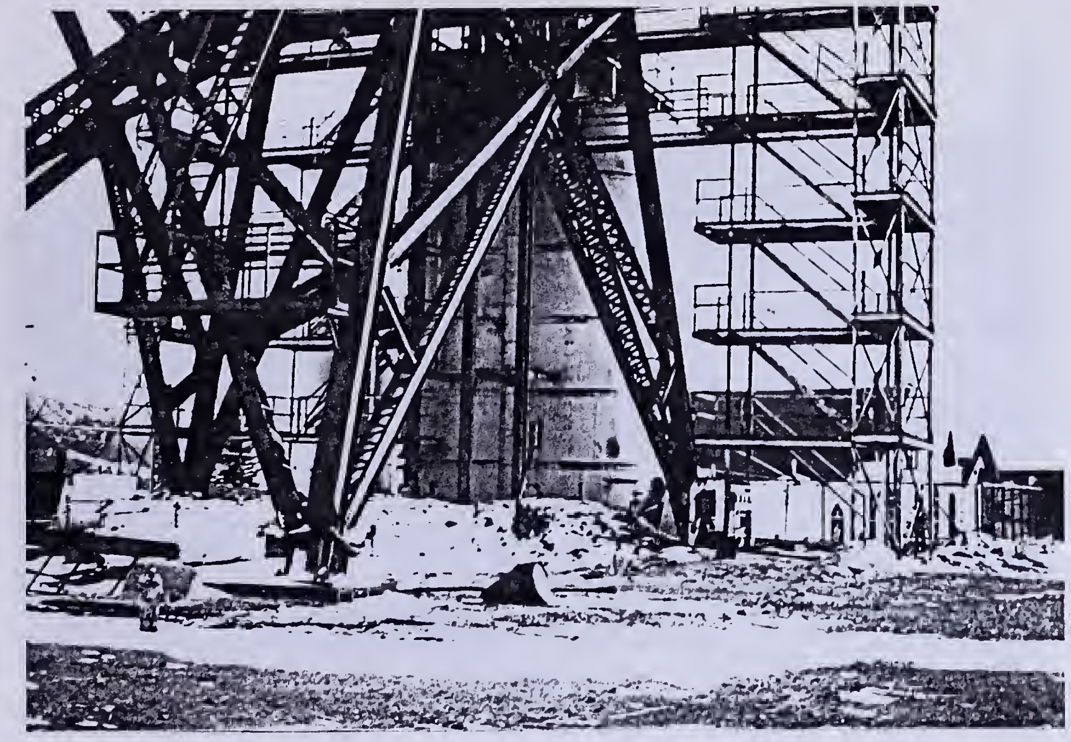
MAP INDEX: Q-27-113

MINE: Lexington

SUBJECT: Headframe, Ore bins, and Shaft Collar

AERIAL PHOTO INDEX: P5-113

PAGE 4 OF 5



SAFETY HAZARD: The shaft collar and bulk-head has been buried with waste rock. The ladders up the head-frame are open

Shaft - see page 1

HEALTH HAZARD: "Bad air" is a possibility (see page 1)

HEALTH HAZARD FACTOR: 3

SAFETY HAZARD FACTOR: 5

MISCELLANEOUS COMMENTS: As an additional note, the tunnel whose portal is in the Syndicate Pit is connected to the Lexington shaft on the 350 foot level. Entrance gained into the tunnel could lead to the shaft.

BUTTE AML PROJECT

AREA: Anselmo - Lexington

VIEW: Looking Northerly

PHOTO NEGATIVE INDEX: G10-17

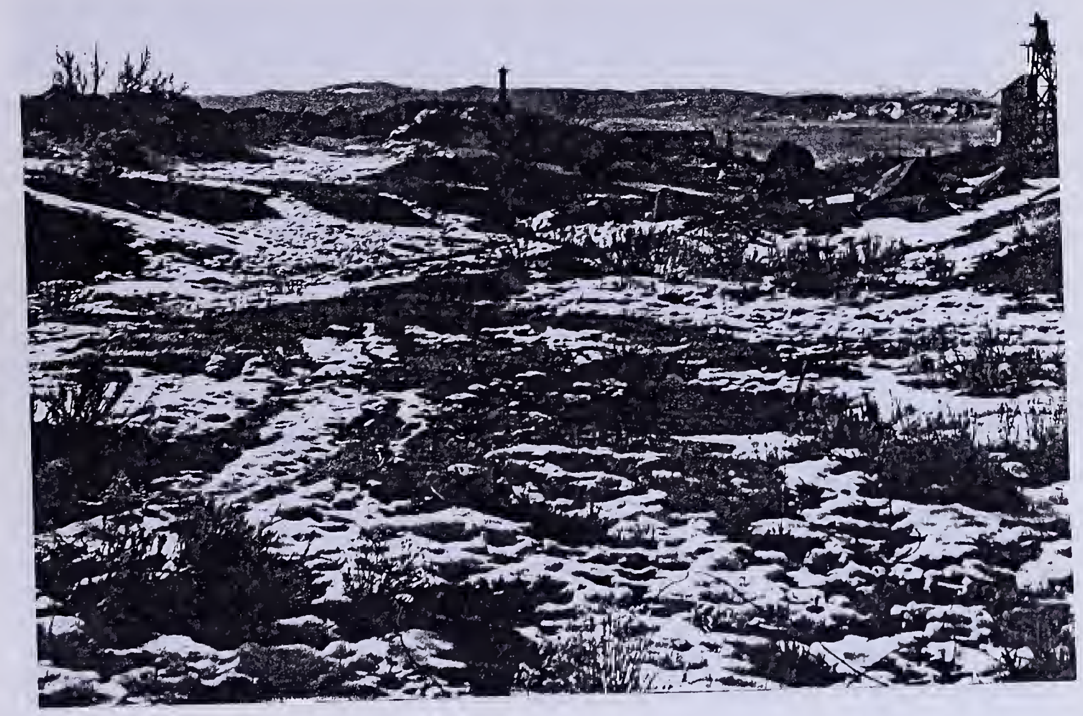
MAP INDEX: Q-27-129

MINE: Lexington

SUBJECT: Sand pass

AERIAL PHOTO INDEX: P6-129

PAGE 5 OF 5



SAFETY HAZARD: The iron grating covers a sand pass to the 500 level of the Lexington mine. The opening may not be filled and, if so, presents a hazard to the public. No fence or protection surrounds the opening.

HEALTH HAZARD: N/A

SAFETY HAZARD FACTOR: 2.5

HEALTH HAZARD FACTOR:

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Anselmo - Lexington

VIEW: Looking Northwesterly

PHOTO NEGATIVE INDEX: G16-16

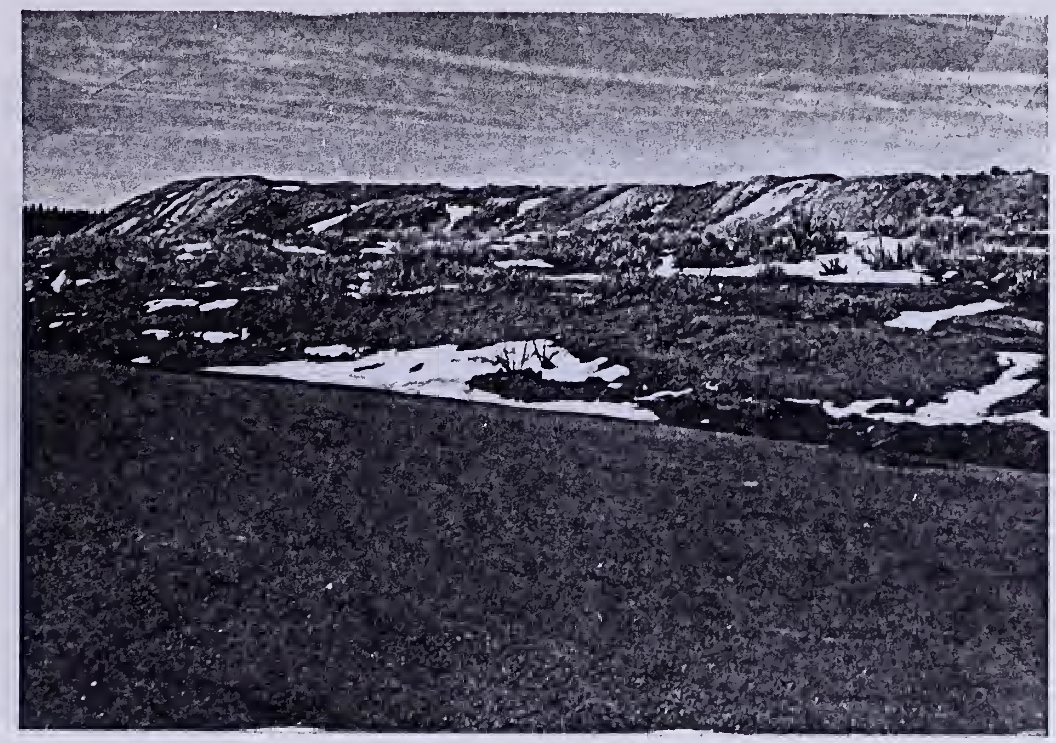
MAP INDEX: M-23-108

MINE: Oro Butte

SUBJECT: Waste Dump

AERIAL PHOTO INDEX: P6-108

PAGE 1 OF 2



HEALTH HAZARD: Thw Oro Butte and Farlen waste dumps, as photographed from Empire Street, present a health hazard from wind-blown dust. The waste dumps are near a heavy populated area.

SAFETY HAZARD: The Oro Butte and Farlen shafts were filled many years ago and do not present any danger from subsidence.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 0

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Anselmo - Lexington

VIEW: Looking South

PHOTO NEGATIVE INDEX: G10-7

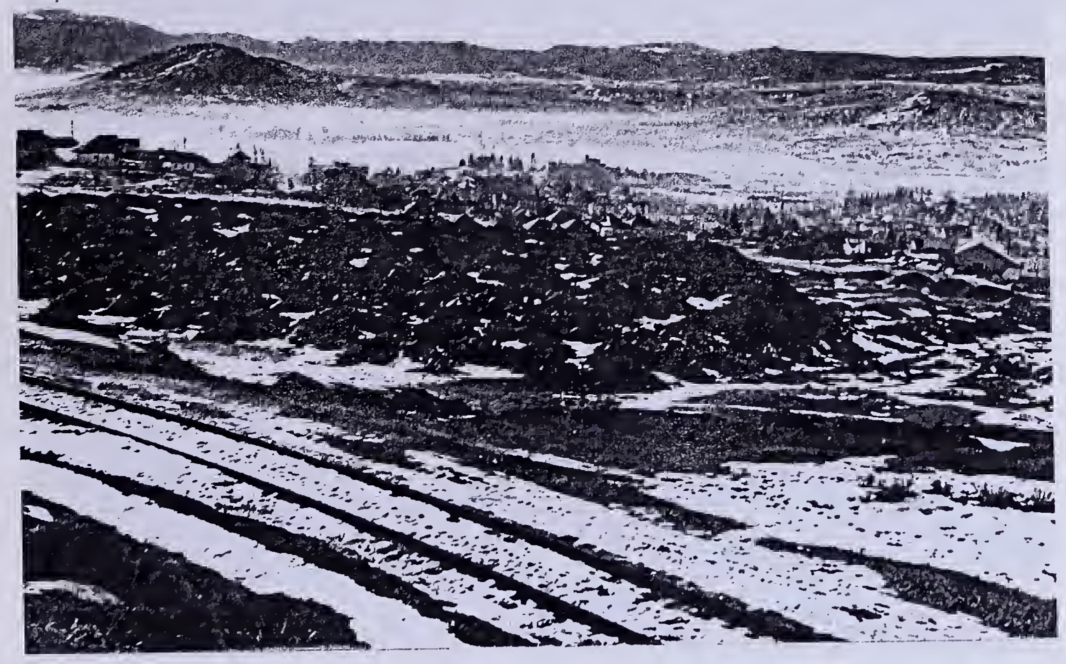
MAP INDEX: M-23-109

MINE: Oro Butte

SUBJECT: Waste Dump

AERIAL PHOTO INDEX: P6-109

PAGE 2 OF 2



HEALTH HAZARD: The photo shows waste material from the transformation of a railroad tunnel under Main Street to an open cut and bridge.

SAFETY HAZARD: Same sd page 1

HEALTH HAZARD FACTOR: 1

SAFETY HAZARD FACTOR: 0

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Anselmo - Lexington

VIEW: Looking Westerly

PHOTO NEGATIVE INDEX: G16-15

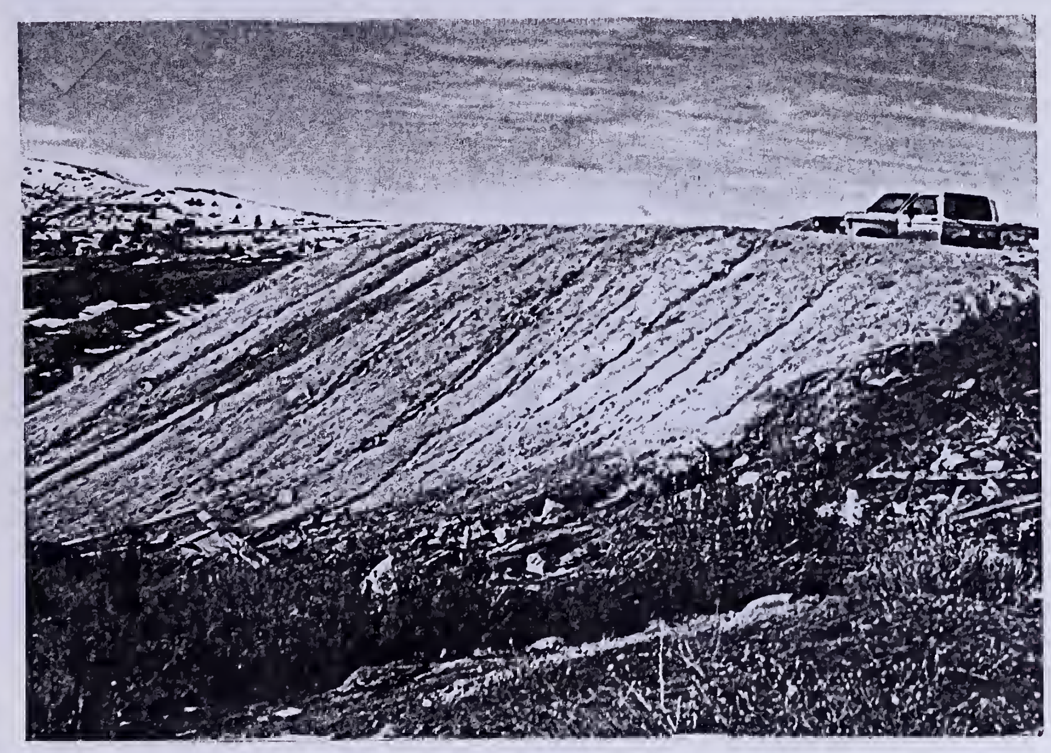
MAP INDEX: M-23-101

MINE: Balmone

SUBJECT: Waste Dump

AERIAL PHOTO INDEX: P6-101

PAGE 1 OF 1



HEALTH HAZARD: Extensive erosion from the dump. The auto in the photo is parked on Empire Street. The dump is quite acidic and dust from wind creates a small health hazard to residences in the near proximity.

SAFETY HAZARD: The shaft was filled many years ago. There is no hazard from subsidence.

HEALTH HAZARD FACTOR: 1

SAFETY HAZARD FACTOR: 0

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Anselmo - Lexington

VIEW: Looking Northeasterly

PHOTO NEGATIVE INDEX: G16-19

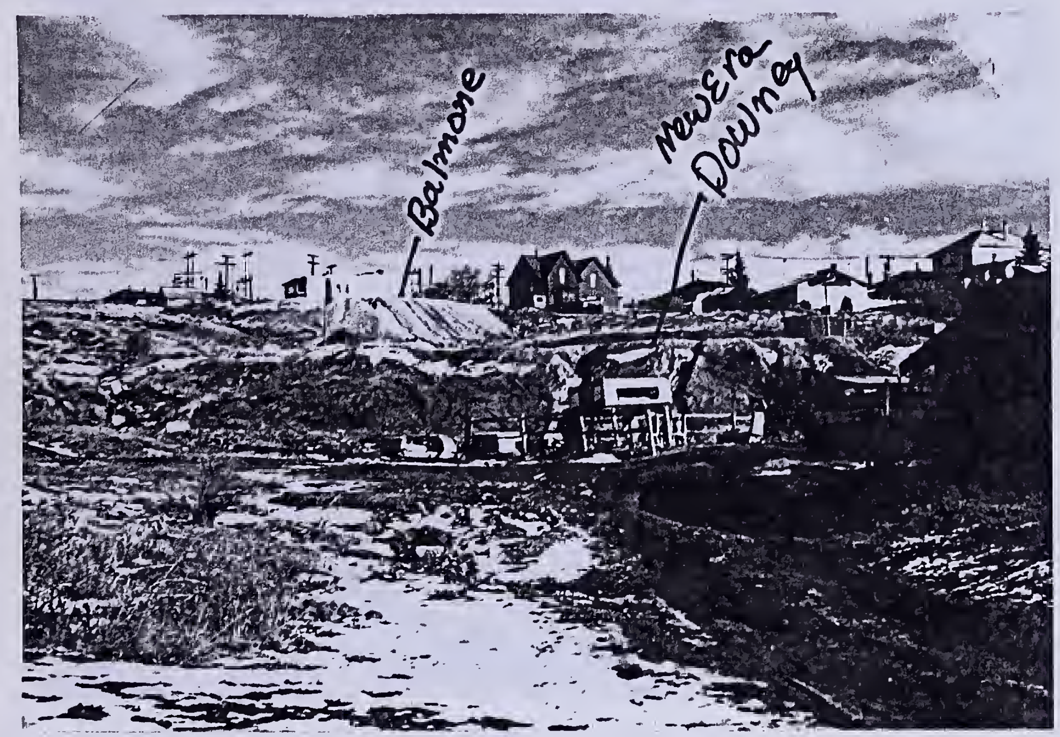
MAP INDEX: M-23-100

MINE: New Era or Downey

SUBJECT: Waste Dump

AERIAL PHOTO INDEX: P6-100

PAGE 1 OF 1



SAFETY HAZARD: The shaft was filled several years ago and presents no danger of caving.

HEALTH HAZARD: The waste dumps are adjacent to several residences. The sediment from runoff accumulates on Boardman Street creating a health hazard from the dust.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 0

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Anselmo - Lexington

VIEW: Looking Northerly

PHOTO NEGATIVE INDEX: G16-17

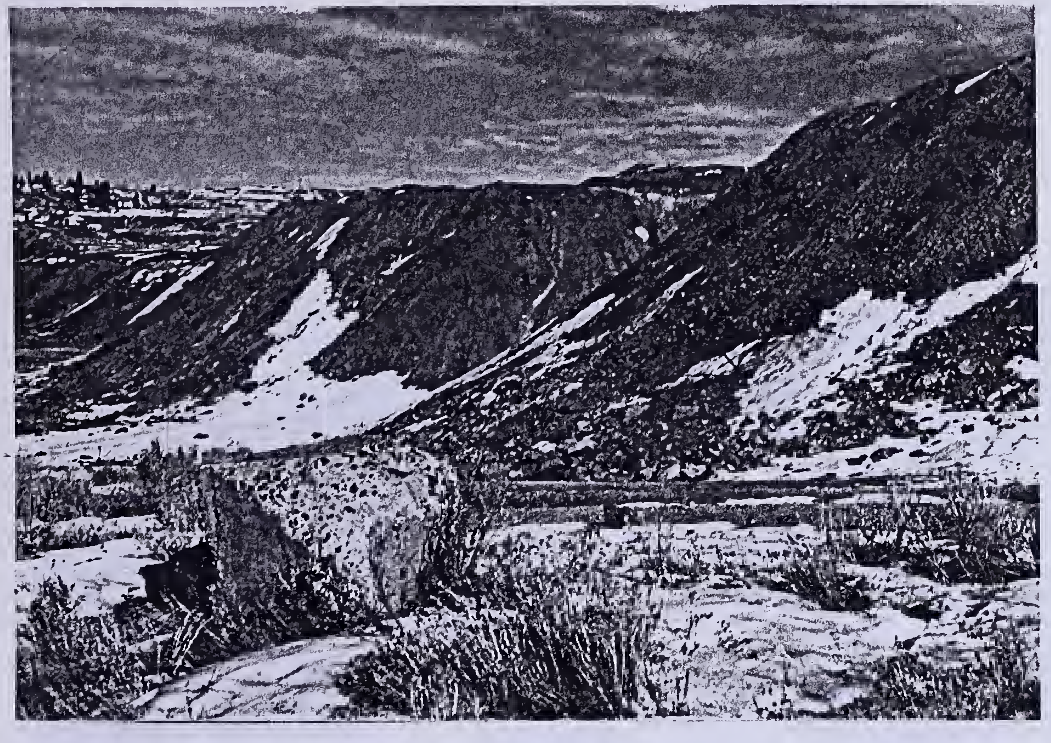
MAP INDEX: M-23-98

MINE: Mount Moriah

SUBJECT: Waste Dumps

AERIAL PHOTO INDEX: P6-98

PAGE 1 OF 1



SAFETY HAZARD: The shaft appears to have been filled many years ago.

HEALTH HAZARD: The waste dump is adjacent to residences and beside a well used street. Dust from blowing wind is injurious to the nearby residences.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 0

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Anselmo - Lexington

VIEW: Looking Southerly

PHOTO NEGATIVE INDEX: G9- 7A

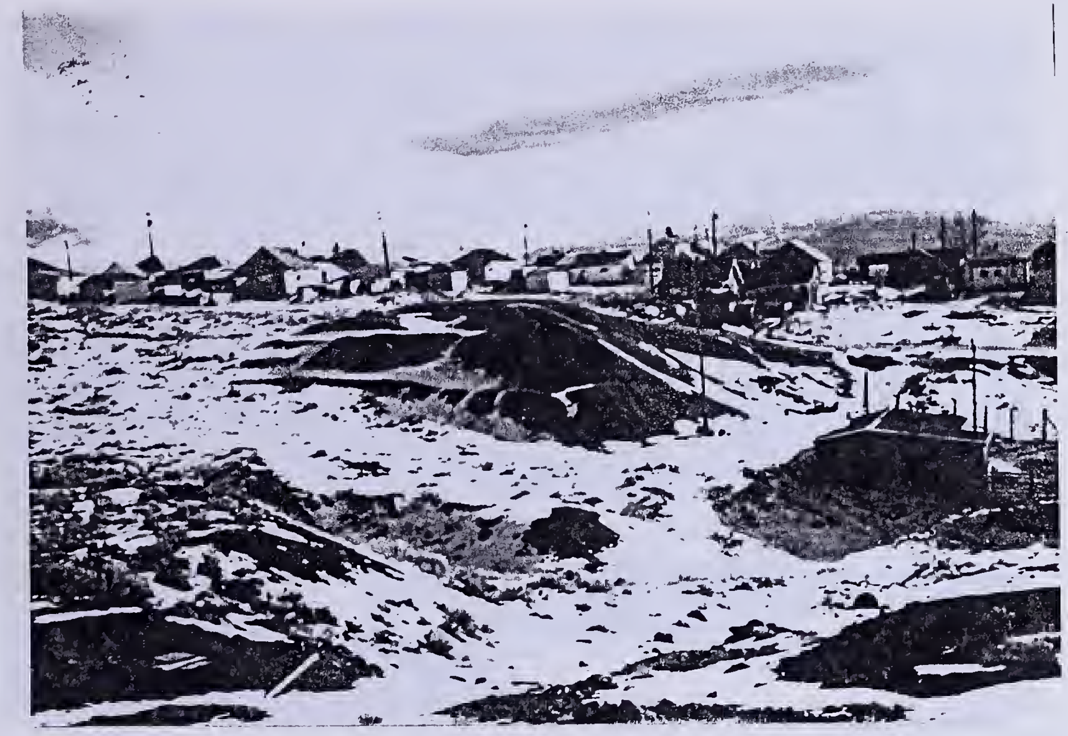
MAP INDEX: Q-23-128

MINE: LaPlata

SUBJECT: Waste Dump

AERIAL PHOTO INDEX: P6-128

PAGE 1 OF 1



HEALTH HAZARD: The waste dump is small and crusted from oxidation and presents only a small health hazard from dusting.

SAFETY HAZARD: The shaft has been filled many years ago and does not present any hazardous condition.

HEALTH HAZARD FACTOR: 1

SAFETY HAZARD FACTOR: 0

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Anselmo - Lexington

VIEW: Looking Northerly

PHOTO NEGATIVE INDEX: G9- 10A

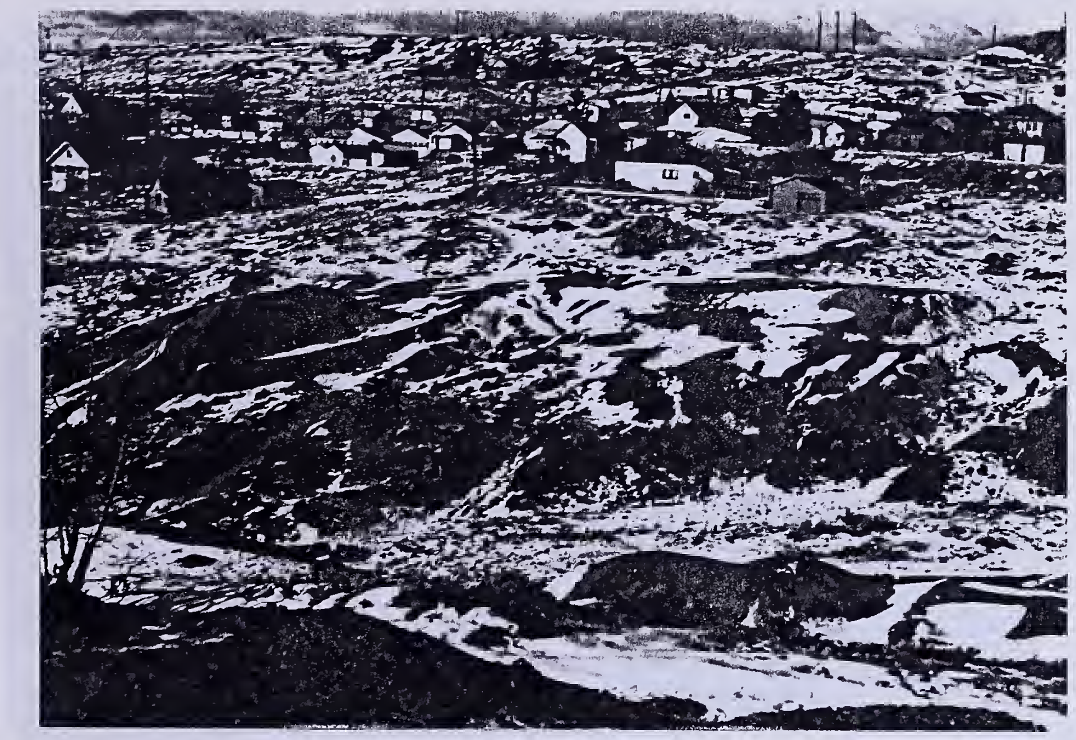
MAP INDEX: Q-23-126

MINE: Wappelo Area

SUBJECT: Misc. Waste Dumps in Gulch

AERIAL PHOTO INDEX: P6-126

PAGE 1 OF 2



HEALTH HAZARD: The numerous waste dumps in the gulch are all acid and will not support vegetation. Dust from prevailing westerly winds is carried to a heavily populated portion of Walkerville.

SAFETY HAZARD: There are many small shafts in the gulch north of the Wappelo shaft area. Most of these have been filled as they caved to the surface but a few might still be hazardous. There are no records concerning these shafts or the filling operation.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 3

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Anselmo - Lexington

VIEW: Northeasterly

PHOTO NEGATIVE INDEX: G9- 8A

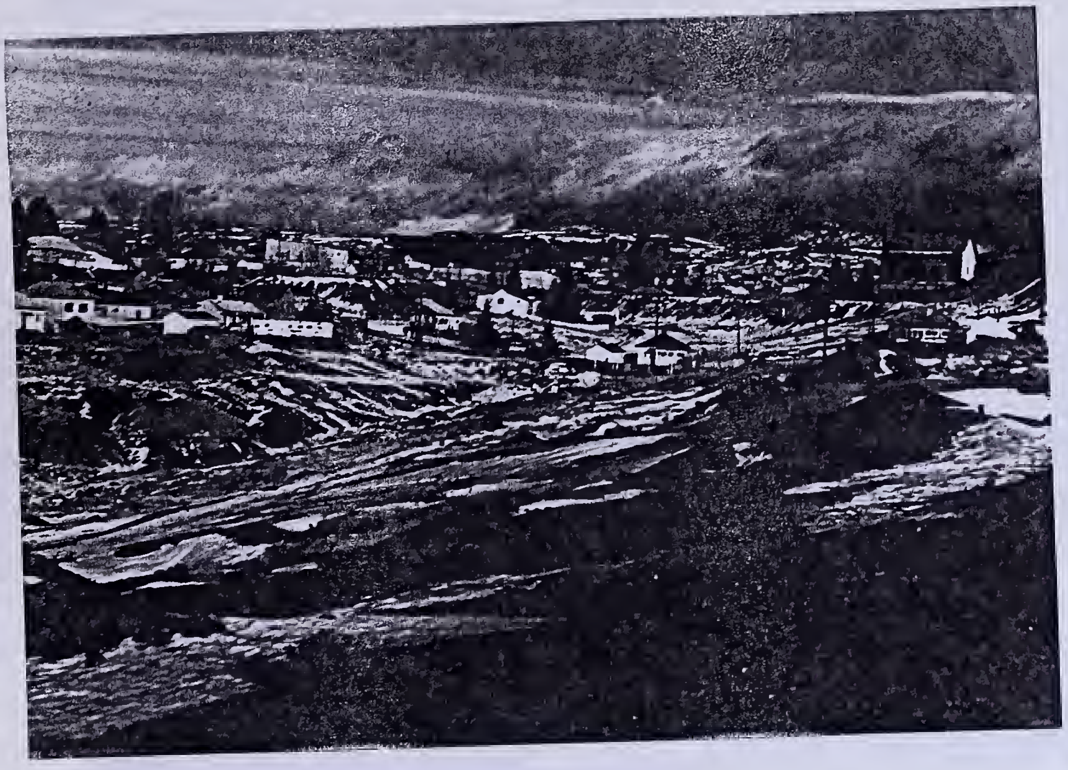
MAP INDEX: Q-23-127

MINE: Wappelo Area

SUBJECT: Misc. Waste Dumps in Gulch

AERIAL PHOTO INDEX: P6-127

PAGE 2 OF 2



HEALTH HAZARD: See page 1

SAFETY HAZARD: See page 1

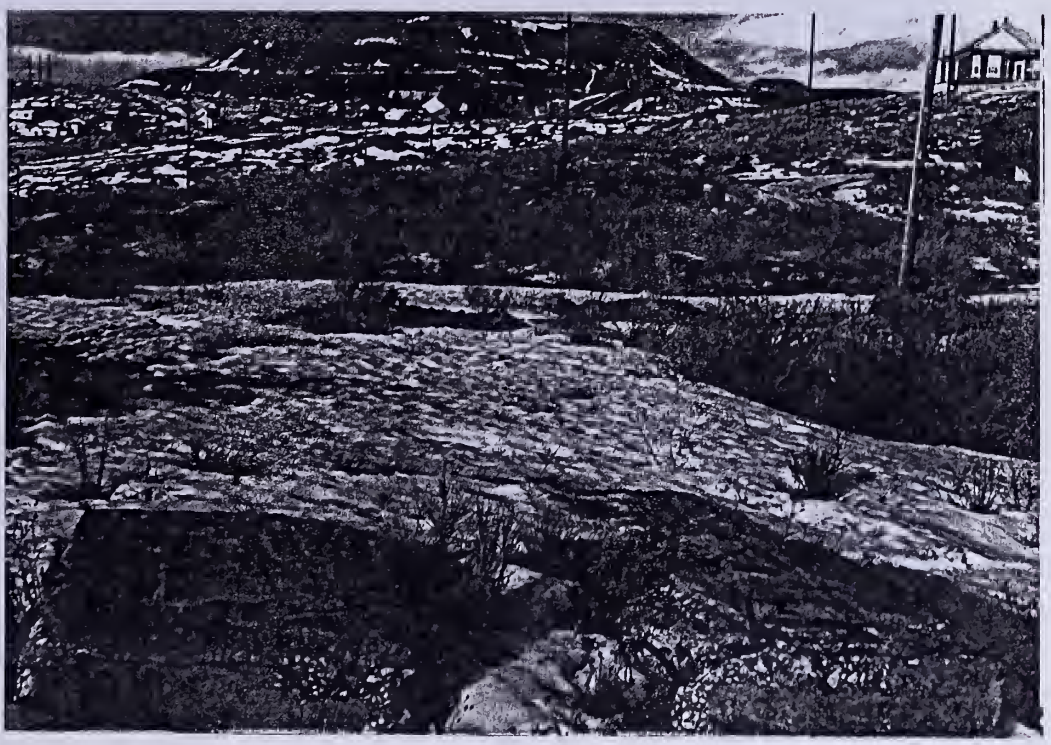
HEALTH HAZARD FACTOR:

SAFETY HAZARD FACTOR:

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Anselmo - Lexington
VIEW: Looking Northerly
PHOTO NEGATIVE INDEX: G9 - 12A
MAP INDEX: Q-23-124
MINE: Ravin
SUBJECT: Engine Base & Shaft Location
AERIAL PHOTO INDEX: P6-124
PAGE 1 OF 2



SAFETY HAZARD: The shaft is 1700 feet deep and from all indications was never filled. There is no evidence of material having been borrowed from the waste pile, which would indicate a filling program. Therefore, the shaft in all probability is bulkheaded either on the surface or close to the surface. The surface or near surface bulkhead will fail and present a very hazardous condition, particularly due to the fact that the shaft is located in close proximity to residences.

HEALTH HAZARD: See page 2

HEALTH HAZARD FACTOR:
SAFETY HAZARD FACTOR: 4
MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Anselmo - Lexington

VIEW: Looking Southeasterly

PHOTO NEGATIVE INDEX: G9-13

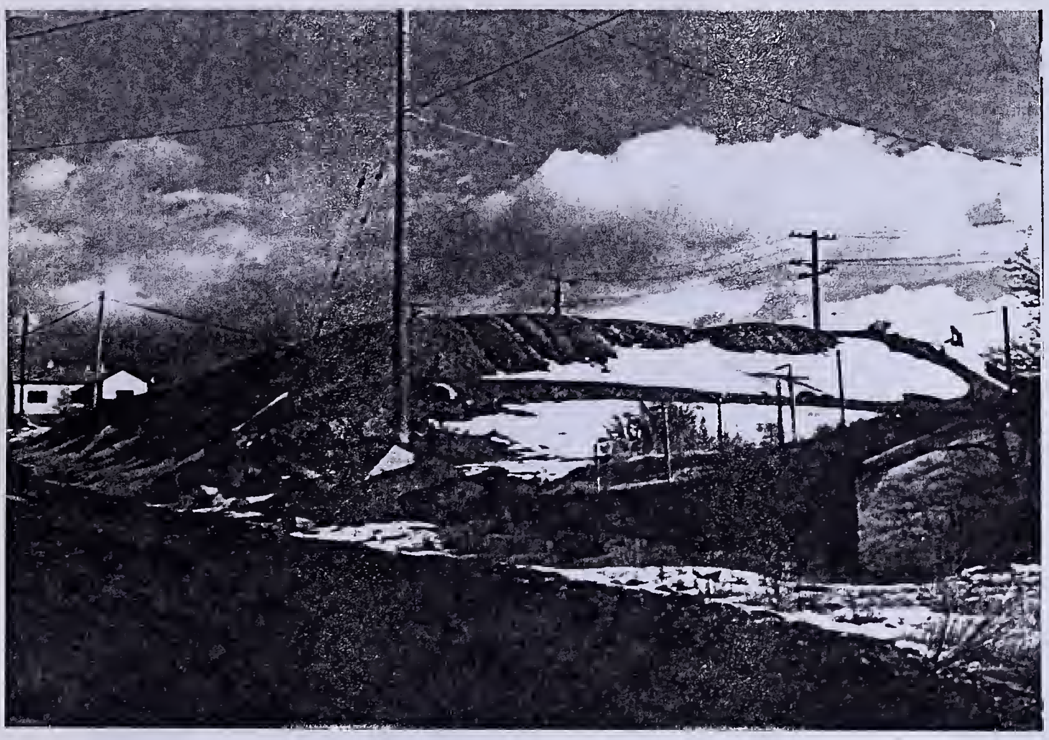
MAP INDEX: Q-23-125

MINE: Ravin

SUBJECT: Waste Dump

AERIAL PHOTO INDEX: P6-126

PAGE 2 OF 2



SAFETY HAZARD: See page 1

HEALTH HAZARD: The waste dump is in close proximity to residences. Wind blown acid dust from the waste dump is a health hazard.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR:

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Anselmo-Lexington

VIEW: Looking Westerly

PHOTO NEGATIVE INDEX: G18-2

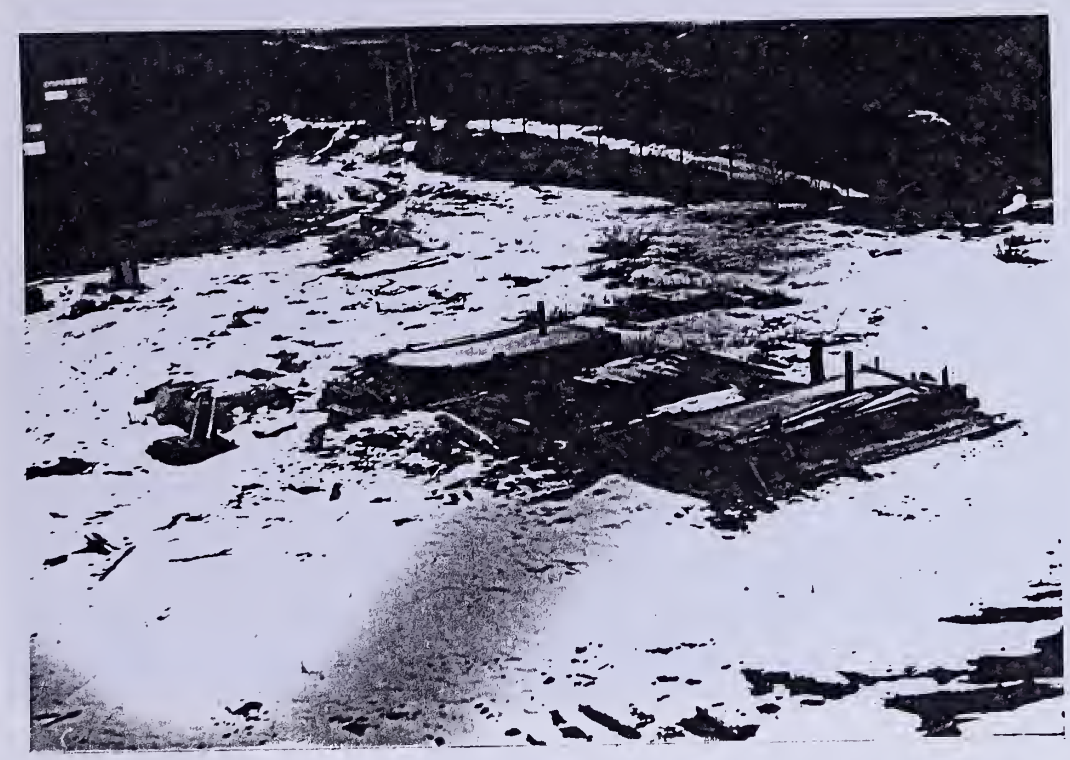
MAP INDEX: M-23-163

MINE: Missoula (Ryan)

SUBJECT: Shaft

AERIAL PHOTO INDEX: P6-163

PAGE 1 **OF** 1



SAFETY HAZARD: The Missoula (Ryan) shaft joins the Alice-Lexington tunnel at 200 feet below the surface and is 500 feet deep. The Alice-Lexington tunnel begins in the Syndicate Pit (see Syndicate Pit). A transfer raise also connects the Alice-Lexington to the surface at 35 feet east of the Missoula (Ryan) shaft. Concrete caps cover both the shaft and raise sized to fit the timber only. The shaft will eventually cave around the concrete cover.

HEALTH HAZARD: N/A

SAFETY HAZARD FACTOR: 4

HEALTH HAZARD FACTOR:

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Anselmo-Lexington

VIEW: Looking Easterly

PHOTO NEGATIVE INDEX: G17-7a

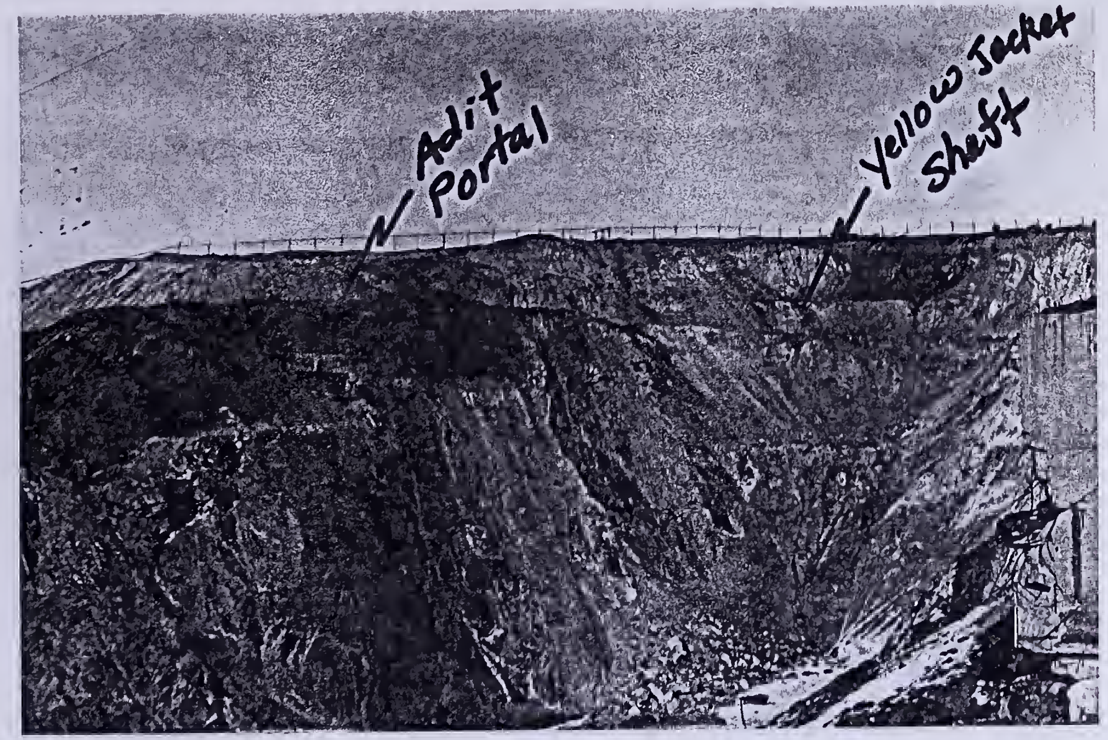
MAP INDEX: M-23-145

MINE: Syndicate Pit

SUBJECT: Pit Walls

AERIAL PHOTO INDEX: P6-145

PAGE 1 OF 4



SAFETY HAZARD: A dangerous steep-walled pit. One hundred fifty to two hundred foot enscarpments. The pit is vulnerable to adjacent residents who have complete access to the pit. Motorcycles, bicycles, and small autos can easily enter the pit through the Empire Street Overpass. (see page 2).

The Lexington portal with locked steel door is vulnerable to vandals and ultimate entrance.

The Yellow Jacket shaft 200 to 300 feet deep, which was cut off below the collar during the pit operation , has caved and a large depression shows on the surface. The shaft will eventually cave further.

HEALTH HAZARD: N/A

HEALTH HAZARD FACTOR:

SAFETY HAZARD FACTOR: 4

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Anselmo - Lexington

VIEW: Looking Northerly

PHOTO NEGATIVE INDEX: G9-21A

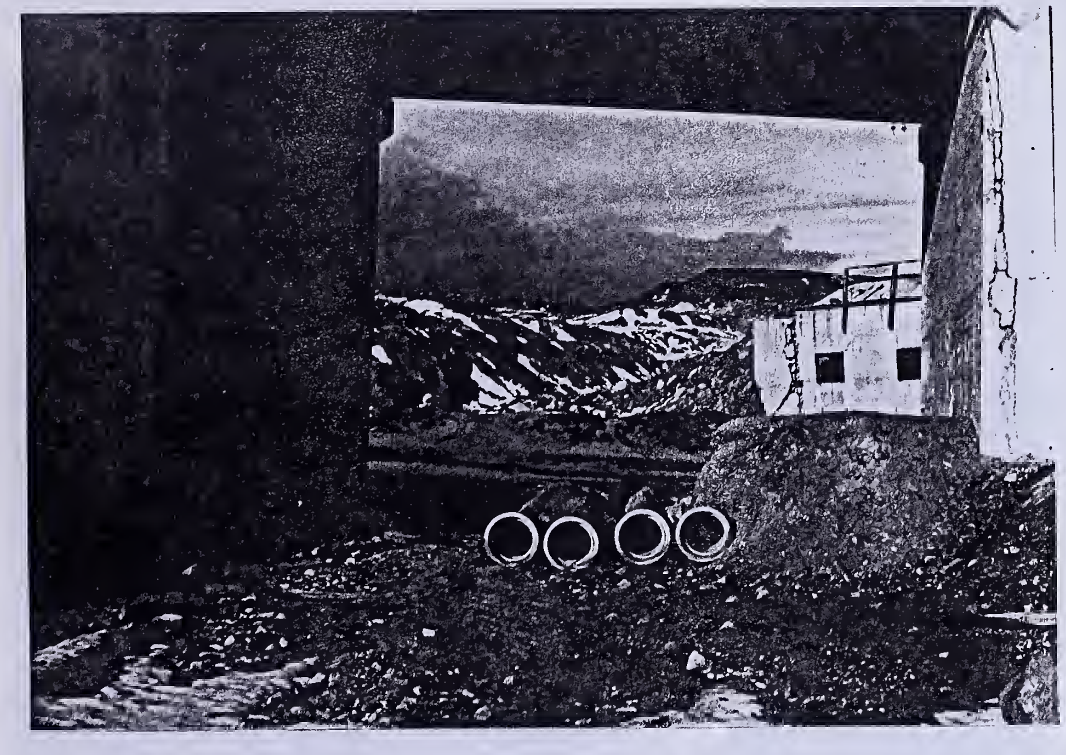
MAP INDEX: M-23-147

MINE: Syndicate Pit

SUBJECT: Underpass - Empire St.

AERIAL PHOTO INDEX: P6-147

PAGE 2 OF 4



SAFETY HAZARD: There is easy entrance to the pit. Vehicles such as small 4-wheel autos, motorcycles and bicycles have easy access through the overpass to almost any section of the pit. Numerous holes in the fence allow easy entrance in other areas of the pit. Such easy access makes the entire pit vulnerable to both nearby residents and others in the Butte area.

HEALTH HAZARD: N/A

HEALTH HAZARD FACTOR:

SAFETY HAZARD FACTOR: 4

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Anselmo-Lexington

VIEW: Looking Northerly

PHOTO NEGATIVE INDEX: G9- 20A

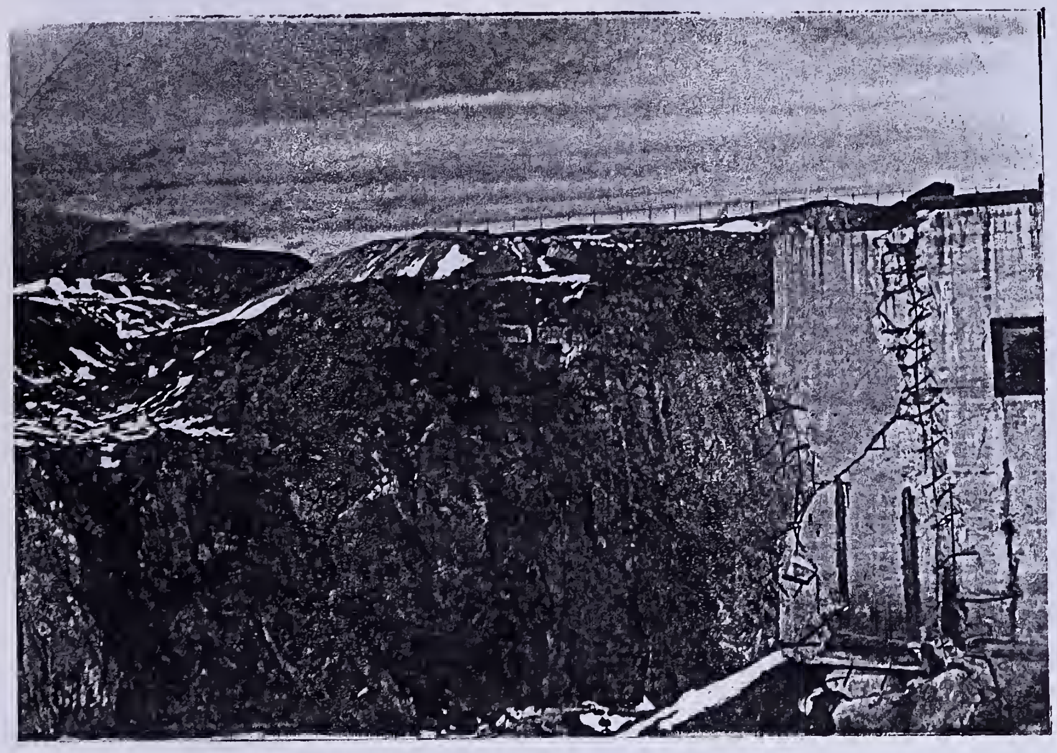
MAP INDEX: M-23-146

MINE: Syndicate

SUBJECT: North Pit Wall and Broken Ore Bin Foundation

AERIAL PHOTO INDEX: P6-146

PAGE 3 OF 4



SAFETY HAZARD: Steep enscarpments and remanent foundations are serious hazards to those entering the pit.

HEALTH HAZARD: N/A

HEALTH HAZARD FACTOR:

SAFETY HAZARD FACTOR: 4

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Anselmo - Lexington

VIEW: Looking Southwesterly

PHOTO NEGATIVE INDEX: G17-6a

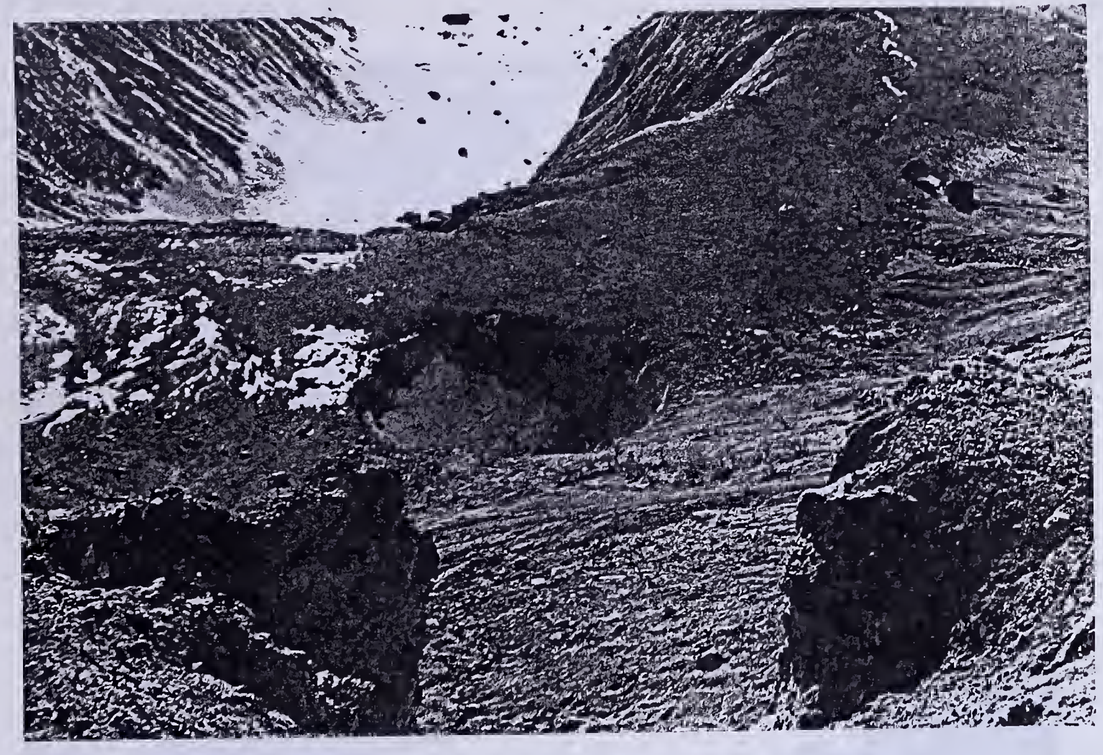
MAP INDEX: M-23-162

MINE: Syndicate Pit

SUBJECT: Yellow Jacket Shaft

AERIAL PHOTO INDEX: P6-162

PAGE 4 OF 4



SAFETY HAZARD: The upper portion of the shaft was cut off during mining procedures in the pit. The shaft was not adequately filled. Subsidence has started as shown on the photo. The shaft is easily accessible to the public through a poorly maintained fence nearby.

HEALTH HAZARD: N/A

HEALTH HAZARD FACTOR:

SAFETY HAZARD FACTOR: 4

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Anselmo - Lexington

VIEW: Looking Northerly

PHOTO NEGATIVE INDEX: G9-14a

MAP INDEX: Q-23-122

MINE: Missoula #2

SUBJECT: Shaft

AERIAL PHOTO INDEX: P6-122

PAGE 1 OF 2

SAFETY HAZARD: The shaft of unknown dep
is boarded over on the surface with dou
three-inch lagging which can be easily
lifted. The shaft, due to its close
proximity to the public with no protection of any kind, is considered to
be very hazardous.

HEALTH HAZARD: N/A

HEALTH HAZARD FACTOR:

SAFETY HAZARD FACTOR: 5

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Anselmo - Lexington

VIEW: Looking Easterly

PHOTO NEGATIVE INDEX: G9-15A

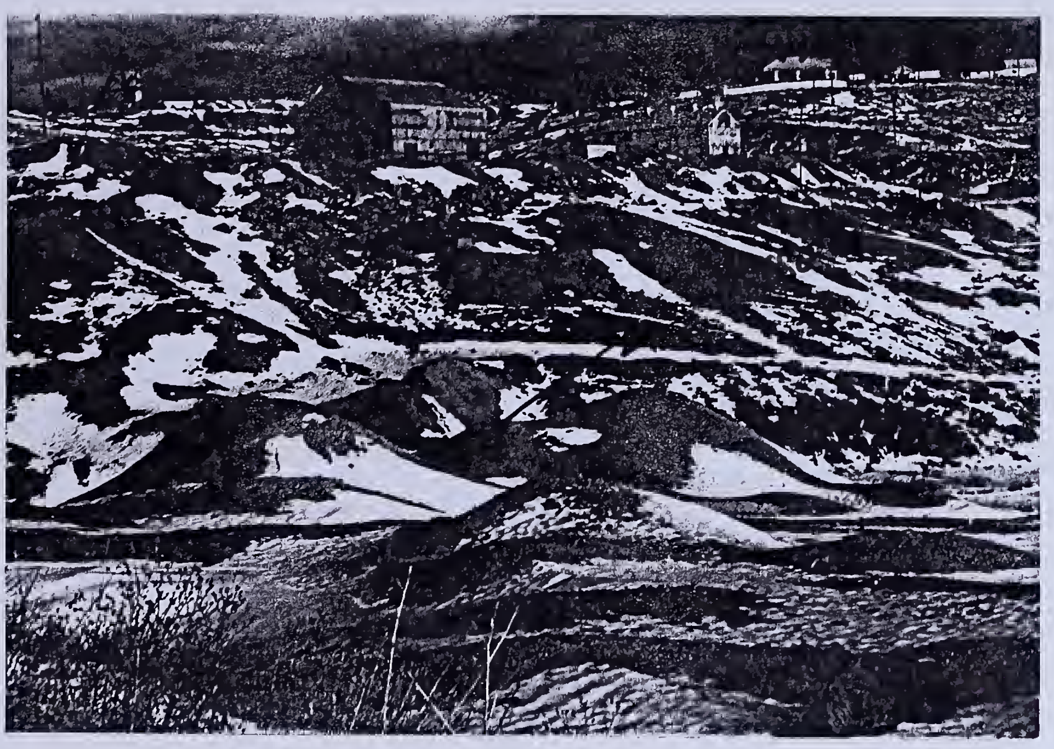
MAP INDEX: Q-23-123

MINE: Missoula

SUBJECT: Shaft Sites

AERIAL PHOTO INDEX: P6-123

PAGE 2 OF 2



SAFETY HAZARD: The Missoula shaft was inclined and filled many years ago.

HEALTH HAZARD: The waste dumps in Missoula Gulch are susceptible to extensive erosion.

HEALTH HAZARD FACTOR: 1

SAFETY HAZARD FACTOR: 0

MISCELLANEOUS COMMENTS:

PIPER & ASSOCIATES, INC.
Mining Industry Consultants
2940 Edwards St., Butte, Montana 59701
(406) 494-5369 or (406) 723-8905

BELMONT AREA

The Belmont Area encompasses that portion of metropolitan Butte from Second Street on the south to Park Street on the north and the Berkeley Mining Permit area on the east to Arizona Street on the west. The mine openings, waste disposal piles and all of the mining units within the area were examined for health and safety hazards.

The Colorado shaft with a 2800 foot depth is the most hazardous site in the Belmont area. The shaft was sealed with a wooden bulkhead and capped with concrete a few feet below the surface and filled from that point to surface with waste rock material, which is presently showing signs of subsidence. The area is open to the public and in close proximity to residences with evidence of children at play.

The Belmont shaft, although fenced, presents the next most hazardous site in the area. The fence does not completely keep the public from entering the mine yard. The shaft has a wooden bulkhead at a point 40 feet below the surface which is the level connecting the hoist house to the shaft. Open steps lead from surface to the 40-foot level allowing access to the shaft below the surface.

The Otisco air shaft, of unknown depth and situated in such a location as to be open to the public, boarded over with 3-inch boards is considered to be the third most important hazard in the Belmont area. The shaft is subject to entrance and eventual caving.

Following these three most hazardous sites in the Belmont area are several smaller shafts that are very hazardous, particularly to children playing in the area. Most of the Belmont area is adjacent to and among residences and very vulnerable to the public.

BUTTE AML PROJECT

AREA: Belmont

VIEW: Looking Southeasterly

PHOTO NEGATIVE INDEX: G7-10

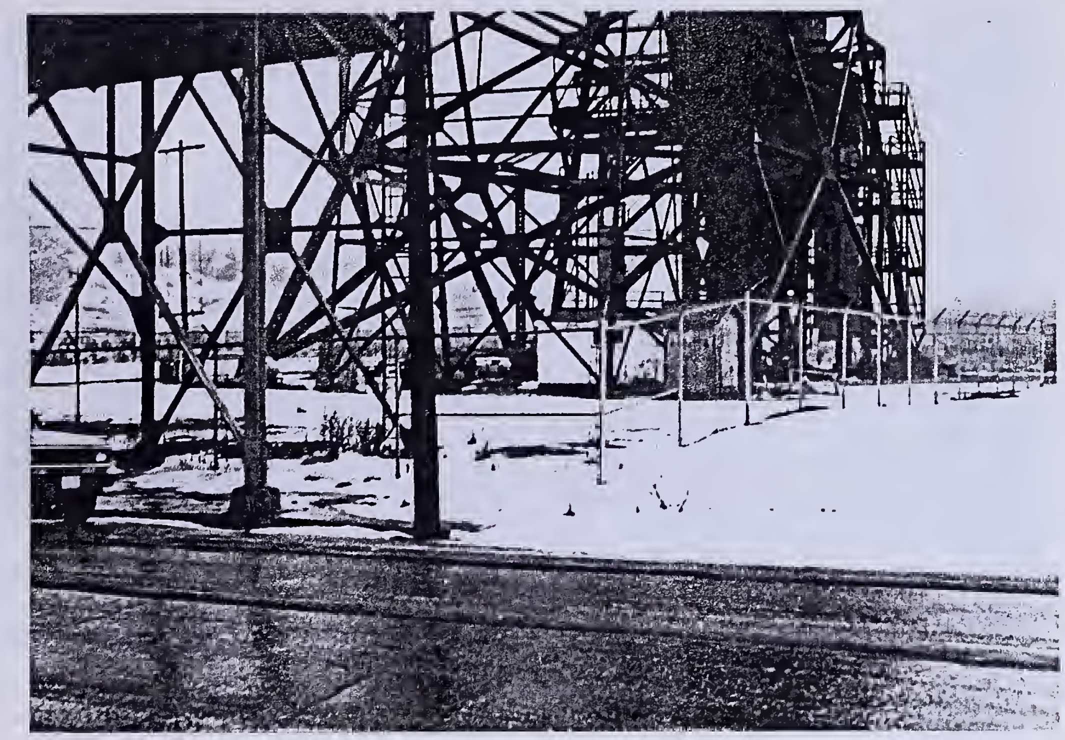
MAP INDEX: I-27-74

MINE: Belmont

SUBJECT: Headframe & Shaft

AERIAL PHOTO INDEX: P3-74

PAGE 1 OF 3



SAFETY HAZARD: There are concrete steps leading down to the 40 foot level. If any portion of the bulkhead should fail a serious hazard would result.

HEALTH HAZARD: There is a possible chance of "bad air" coming up the shaft as the water level rises.

HEALTH HAZARD FACTOR: 4

SAFETY HAZARD FACTOR: 4

MISCELLANEOUS COMMENTS:

AREA: Belmont

VIEW: Looking Southerly

PHOTO NEGATIVE INDEX: G-14-1

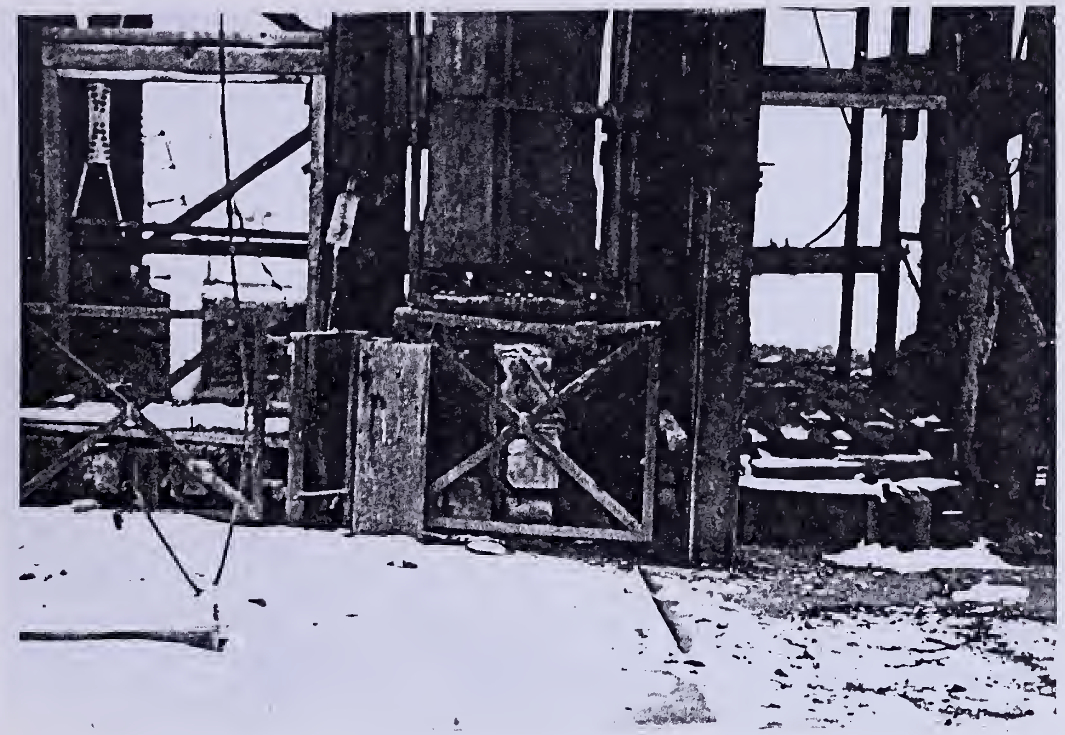
MAP INDEX: I-27-75

MINE: Belmont

SUBJECT: Shaft Collar

AERIAL PHOTO INDEX: P3-75

PAGE 2 OF 3



SAFETY HAZARD: The shaft is bulkheaded on the 40 foot level and bulkheaded on the surface with 8" x 8" timber. The man-cages rest on the 8" x 8" timber but the manway (left shaft compartment in the photo) is covered by the 8" x 8" timber not tied down in any way. The manway is vulnerable to entrance. The shaft is 4300 feet deep and probably will fill with water to 200 ft. below the surface.

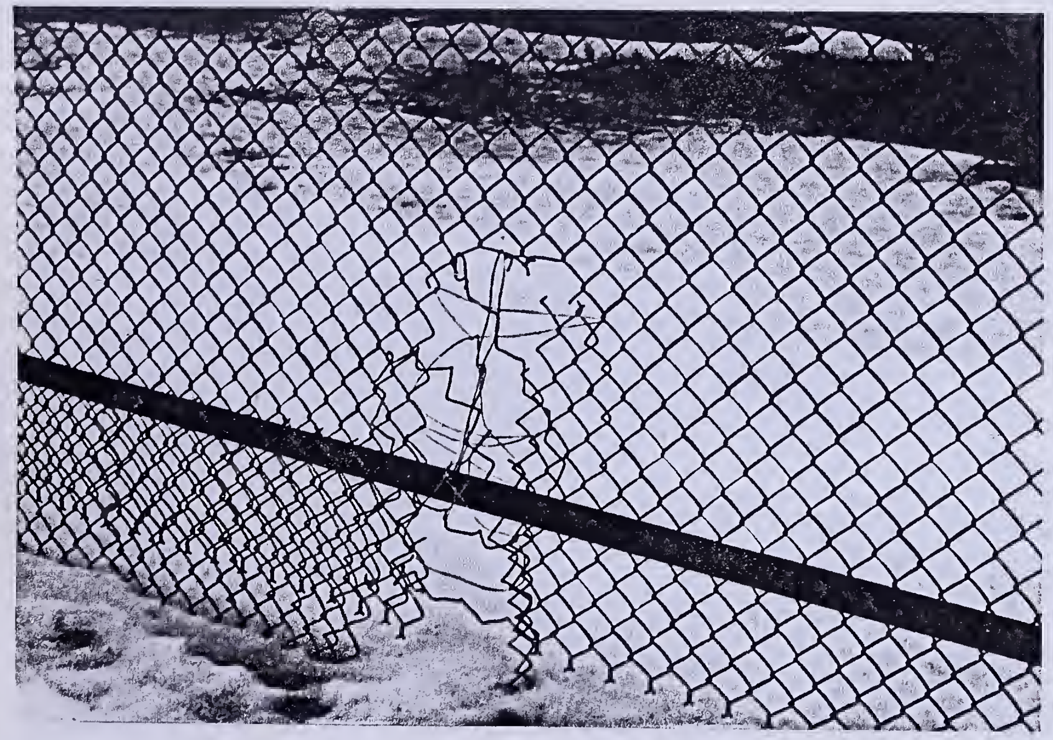
HEALTH HAZARD: See page 1

HEALTH HAZARD FACTOR: 4

SAFETY HAZARD FACTOR: 4

MISCELLANEOUS COMMENTS:

AREA: Belmont
VIEW: Looking West
PHOTO NEGATIVE INDEX: G7-11
MAP INDEX: I-27-76
MINE: Belmont
SUBJECT: East Fence
AERIAL PHOTO INDEX: P3-76
PAGE 3 OF 3



SAFETY HAZARD: The fence is easily scaled as well as being vulnerable to cutting. There is evidence in the area showing entrance by the public.

HEALTH HAZARD: See page 1

HEALTH HAZARD FACTOR:
SAFETY HAZARD FACTOR: 4
MISCELLANEOUS COMMENTS:

AREA: Belmont

VIEW: Looking Northwesterly

PHOTO NEGATIVE INDEX: G9-2A

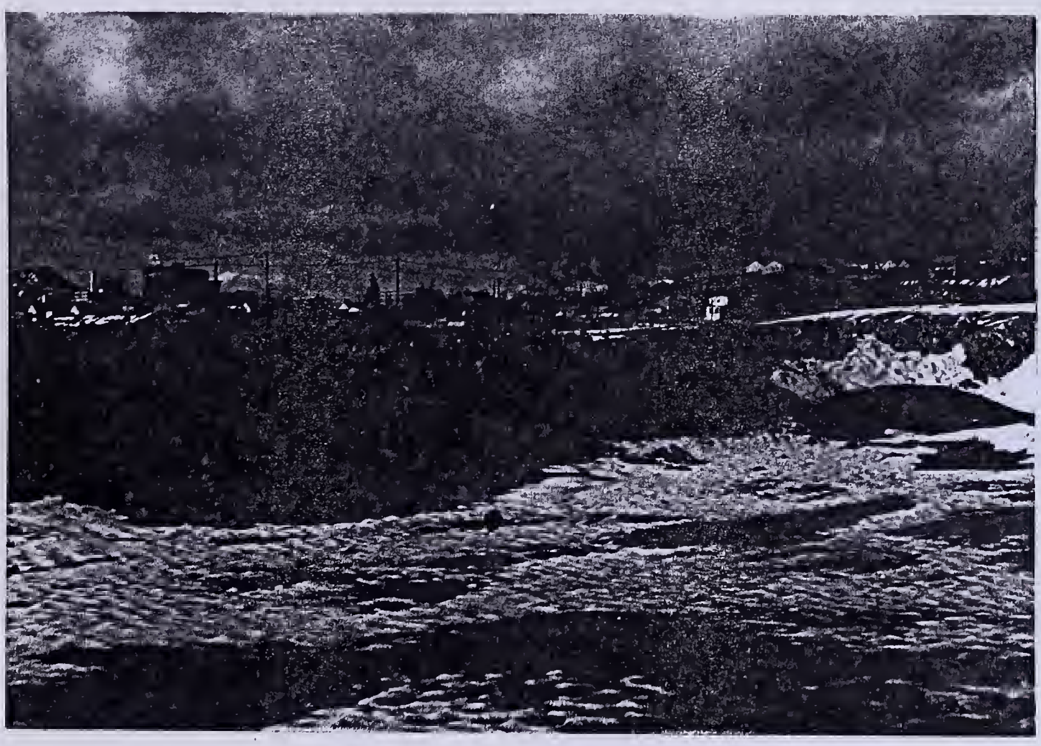
MAP INDEX: I-27-47

MINE: Anderson

SUBJECT: Waste Dump

AERIAL PHOTO INDEX: P3-47

PAGE 1 OF 1



SAFETY HAZARD: The shaft, 300 feet deep, was filled several years ago. A portion of the waste dump was used for fill material.

HEALTH HAZARD: The waste dump is considerably acid and subject to dusting from prevalent northwest wind. The path of the wind carries the dust to populated areas east of Texas Avenue.

HEALTH HAZARD FACTOR: 1.5

SAFETY HAZARD FACTOR: 0

MISCELLANEOUS COMMENTS:

AREA: Belmont

VIEW: Looking Easterly

PHOTO NEGATIVE INDEX: G9- 3A

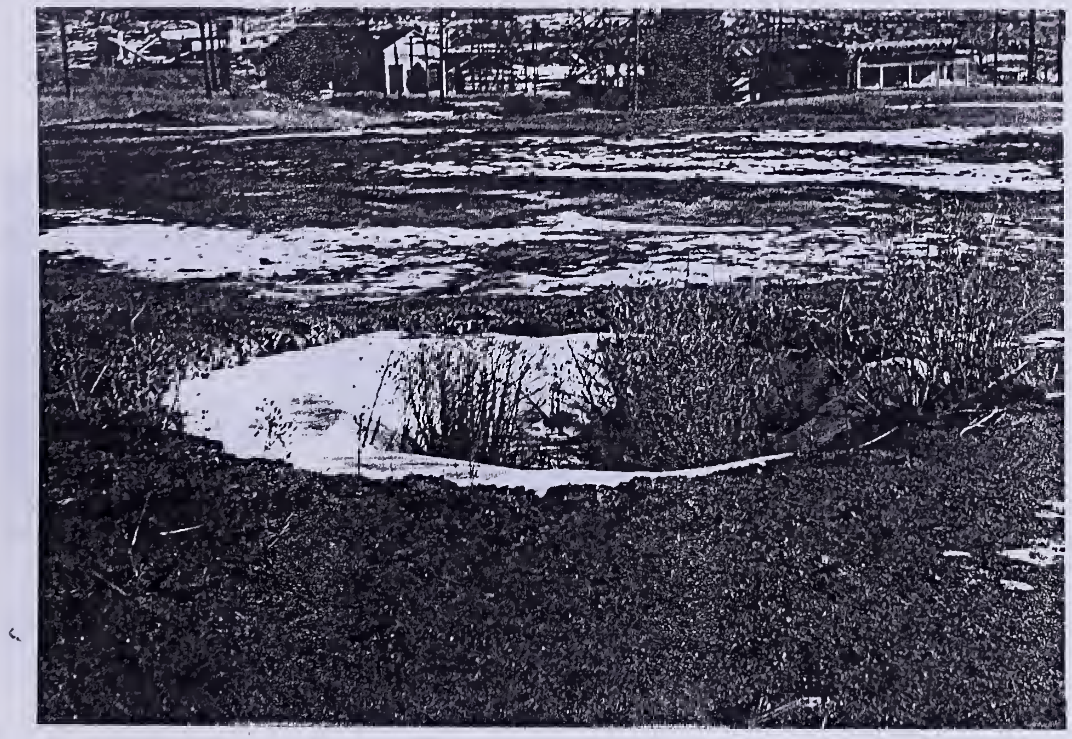
MAP INDEX: I-27-48

MINE: Hickey

SUBJECT: Shaft - subsidence

AERIAL PHOTO INDEX: P6-48

PAGE 1 OF 1



SAFETY HAZARD: The shaft collar has subsided during the past year or so leaving a depression that could further cave. The surface or near surface bulkhead probably failed allowing the surface to cave. The area is open to the public along East Park Street and could be a hazard if any further caving takes place. The shaft is only 200 feet deep, therefore not of an extremely critical condition.

HEALTH HAZARD: N/A

HEALTH HAZARD FACTOR:

SAFETY HAZARD FACTOR: 2

MISCELLANEOUS COMMENTS:

AREA: Belmont

VIEW: Looking Northeasterly

PHOTO NEGATIVE INDEX: G8-14

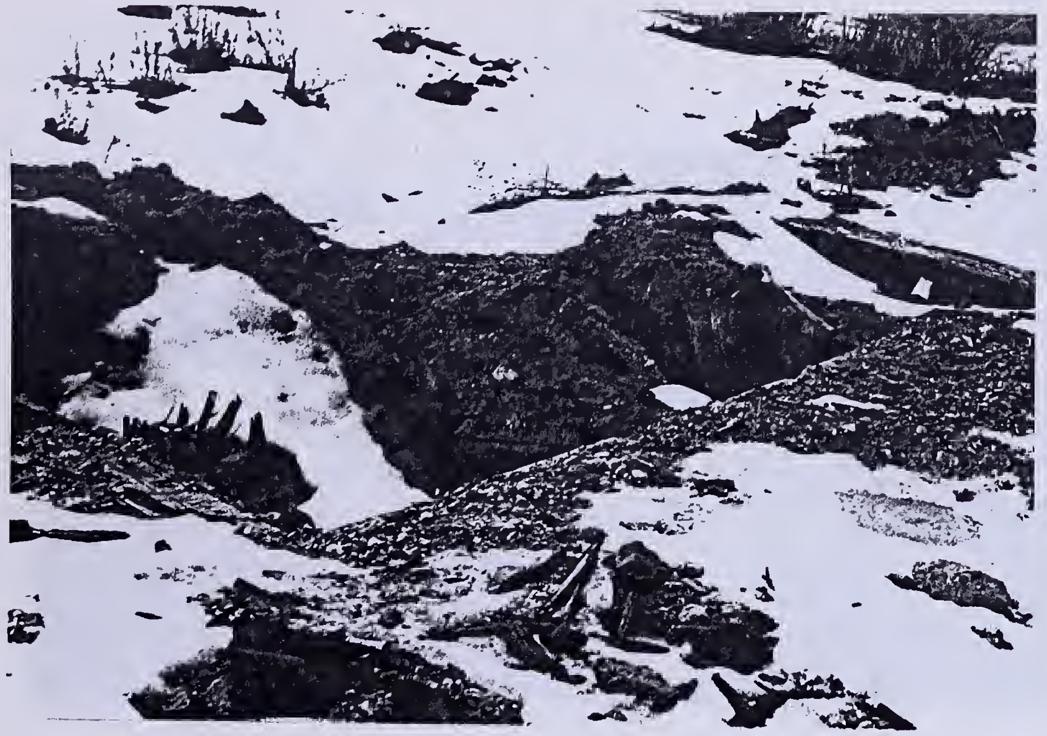
MAP INDEX: I-27-49

MINE: Colorado

SUBJECT: Shaft Collar

AERIAL PHOTO INDEX: P6-49

PAGE 1 OF 5



HEALTH HAZARD: According to reports, whenever there was a sanitary sewer problem northeast of the shaft, raw sewage entered the shaft, indicating a connection of some sort.

SAFETY HAZARD: There is a wooden bulkhead covered with unreenforced concrete at a point 40 feet below the surface. The concrete bulkhead was not hitched into the walls of the shaft. The bulkhead will rot and eventually fail. The photo shows evidence of subsidence of the fill material indicating that the bulkhead has begun to fail.

Waste material placed on the concrete and wooden bulkhead causes accelerated wood rot and subsequent failure.

The shaft is 2800 feet deep vertically. There is no protection of the shaft from the public.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 5

MISCELLANEOUS COMMENTS:

AREA: Belmont

VIEW: Looking Northwesterly

PHOTO NEGATIVE INDEX: G8-16

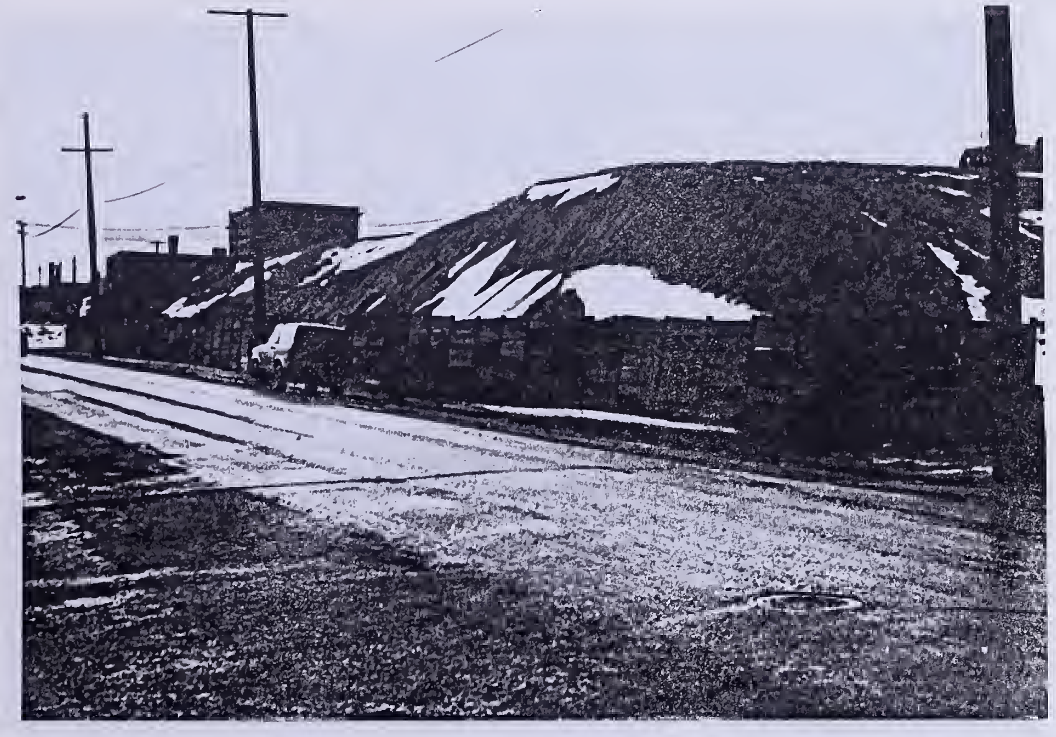
MAP INDEX: I-27-50

MINE: Colorado

SUBJECT: Waste Dump

AERIAL PHOTO INDEX: P6-50

PAGE 2 OF 5



SAFETY HAZARD: See page 1

HEALTH HAZARD: The rail and board fence along Mercury Street on the south side of the Colorado waste dump allows considerable sand and acid water to leak through onto the sidewalk. (see pages 3 and 4).

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR:

MISCELLANEOUS COMMENTS:

AREA: Belmont

VIEW: Looking Easterly

PHOTO NEGATIVE INDEX: G11-6

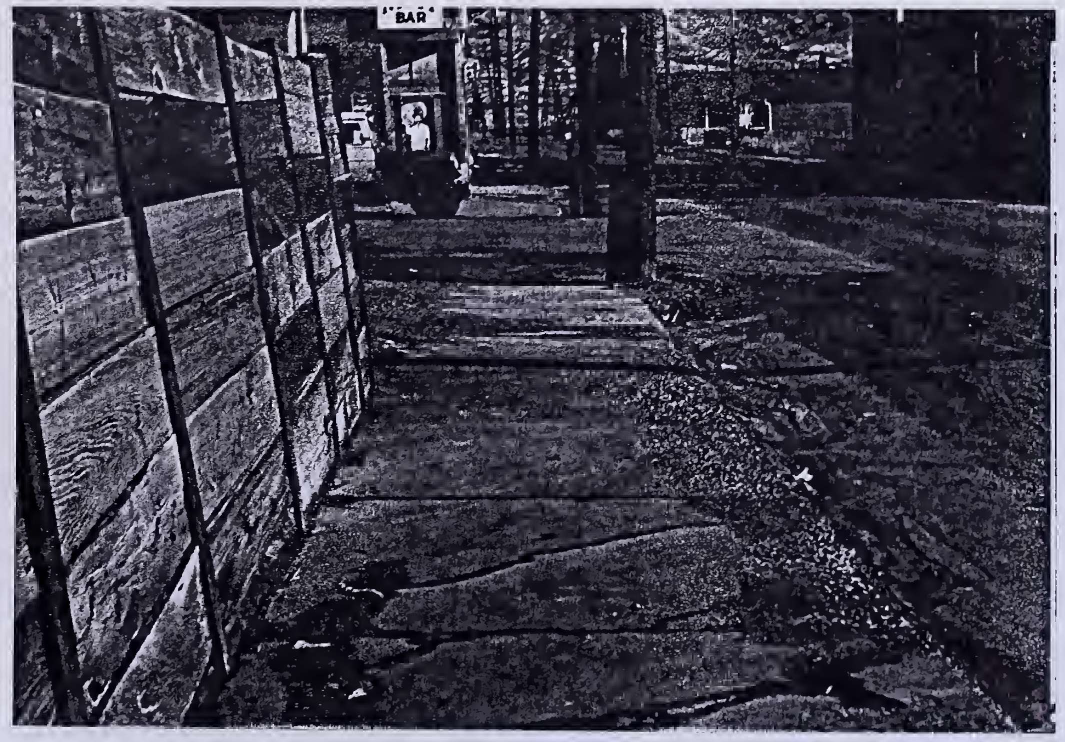
MAP INDEX: I-27-51

MINE: Colorado

SUBJECT: Wash from Waste Dump

AERIAL PHOTO INDEX: P6-51

PAGE 3 OF 5



SAFETY HAZARD: See page 1

HEALTH HAZARD: Acid water and sand from the waste dump creates an injurious dust condition. (Note staining and sand on the sidewalk).

Note - Metro Sewer problem

HEALTH HAZARD FACTOR: 2

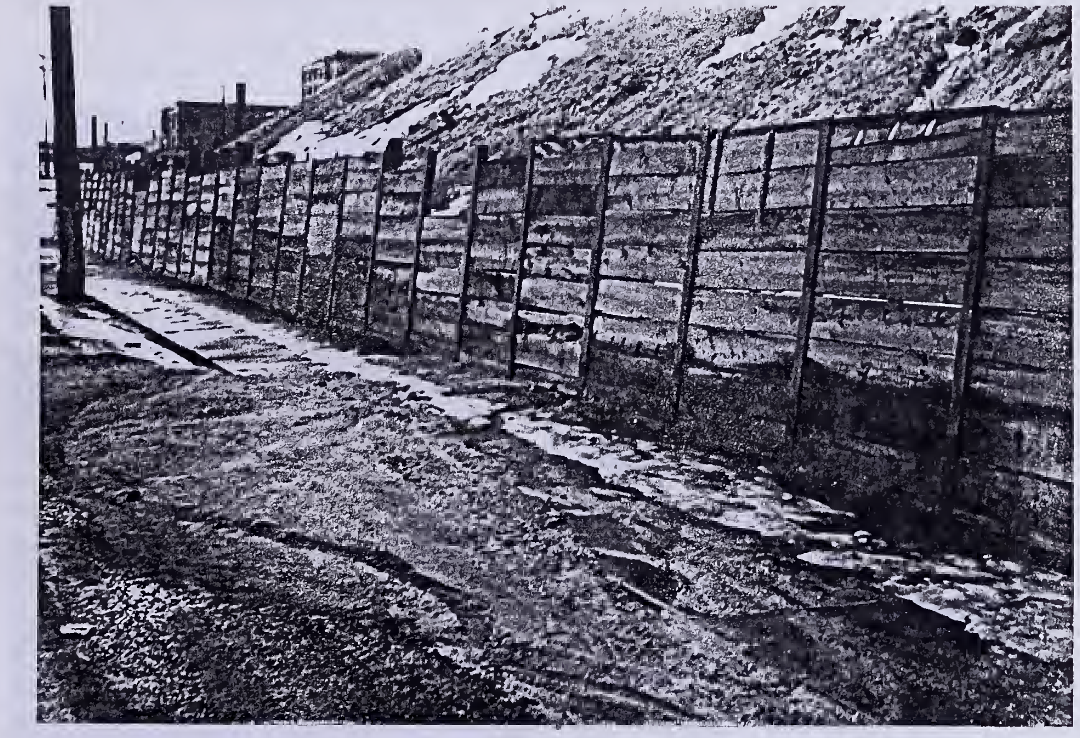
SAFETY HAZARD FACTOR:

MISCELLANEOUS COMMENTS:

AREA: Belmont
VIEW: Looking Westerly
PHOTO NEGATIVE INDEX: G8-21
MAP INDEX: I-27-53

MINE: Colorado
SUBJECT: Wash from Waste Dump
AERIAL PHOTO INDEX: P6-53

PAGE 4 OF 5



SAFETY HAZARD: See page 1

HEALTH HAZARD: Same as page 3

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR:

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Belmont

VIEW: Looking Southeasterly

PHOTO NEGATIVE INDEX: G8-13

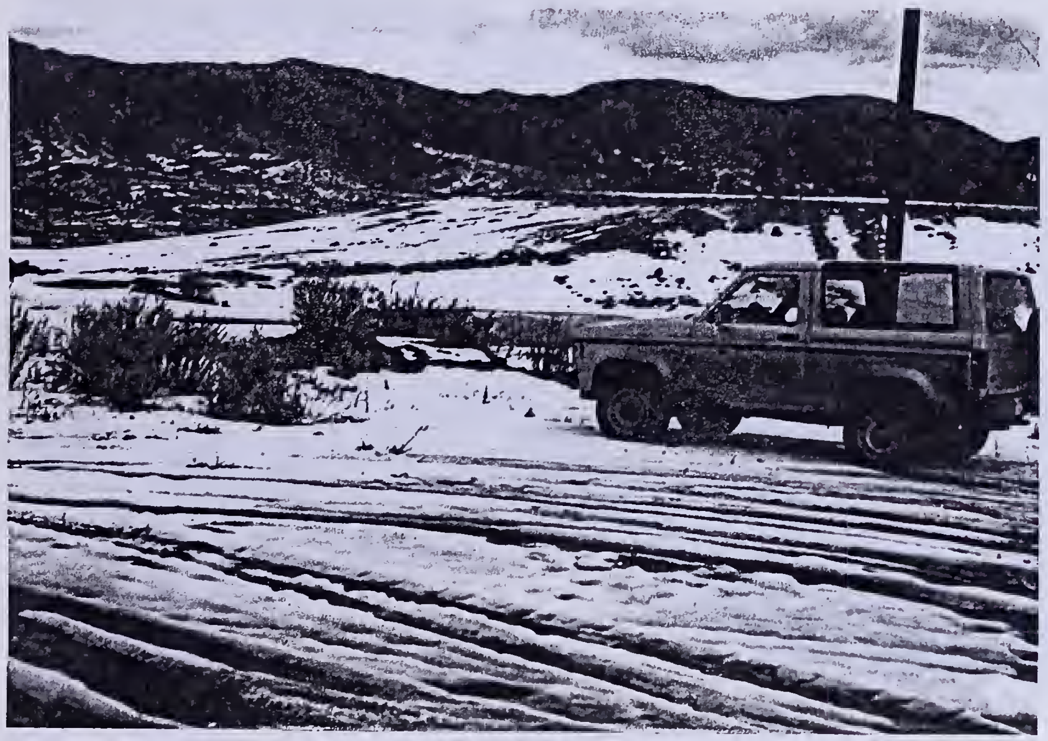
MAP INDEX: I-27-52

MINE: Colorado

SUBJECT: Davis-Daly air shaft & Colorado waste dump

AERIAL PHOTO INDEX: P6-13

PAGE 5 OF 5



HEALTH HAZARD: Dusting from the reworked area containing acid material is a health hazard to the adjacent homes.

SAFETY HAZARD: The Davis-Daly air shaft was open at the surface and covered only with double 3-inch boards. Several years ago when the dump was reshaped several feet of waste rock was pushed on top of the cover. The cover will rot and fail in a few years and the shaft which is approximately 200 to 300 feet deep will be exposed to the surface. The area is unprotected from the public and is a severe safety hazard.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 4

MISCELLANEOUS COMMENTS:

AREA: Belmont

VIEW: Looking Southeasterly

PHOTO NEGATIVE INDEX: G15-9

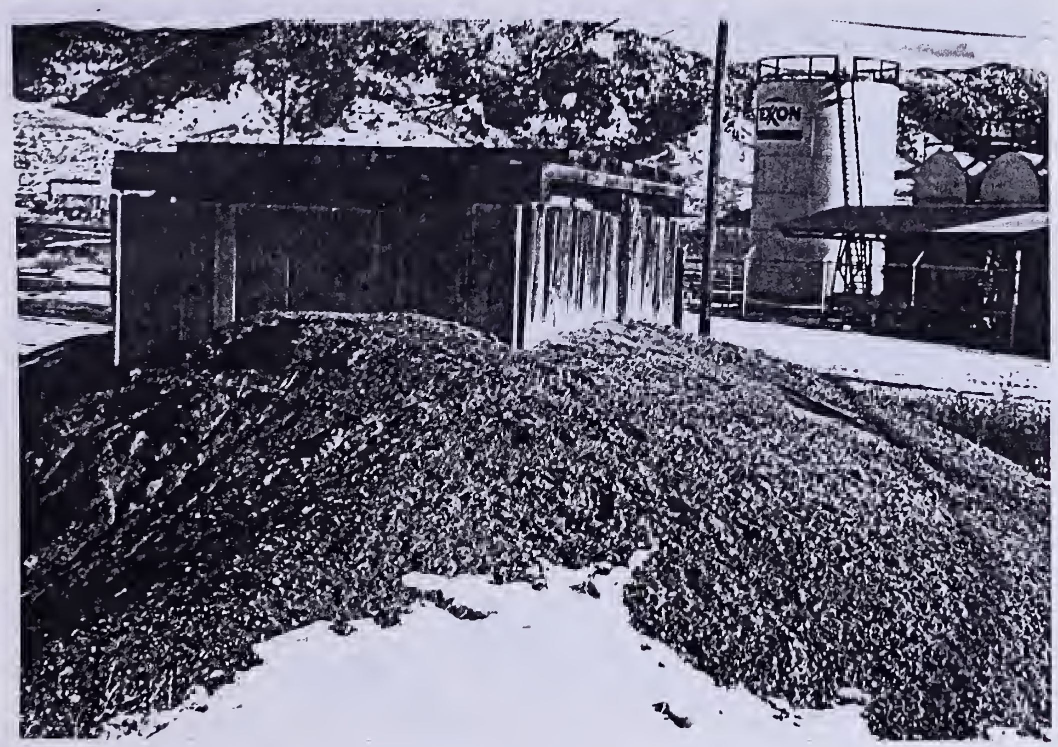
MAP INDEX: I-27-77

MINE: Otisco #2 (Air)

SUBJECT: Shaft Collar

AERIAL PHOTO INDEX: P3-77

PAGE 1 OF 1



SAFETY HAZARD: The shaft is of unknown depth but to be an air shaft for the Otisco it must be a 100 feet deep or more. The surface structure is inadequately covered by double 3-inch boards only. There is no appearance of a bulkhead. The shaft is completely exposed to the public, it is a hazard both from a possible caving action and being susceptible to entrance.

HEALTH HAZARD: There is a strong possibility that the shaft contains "bad air" and due to the easy entrance is a health hazard.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 4

MISCELLANEOUS COMMENTS:

AREA: Belmont

VIEW: Looking South

PHOTO NEGATIVE INDEX: G15-7

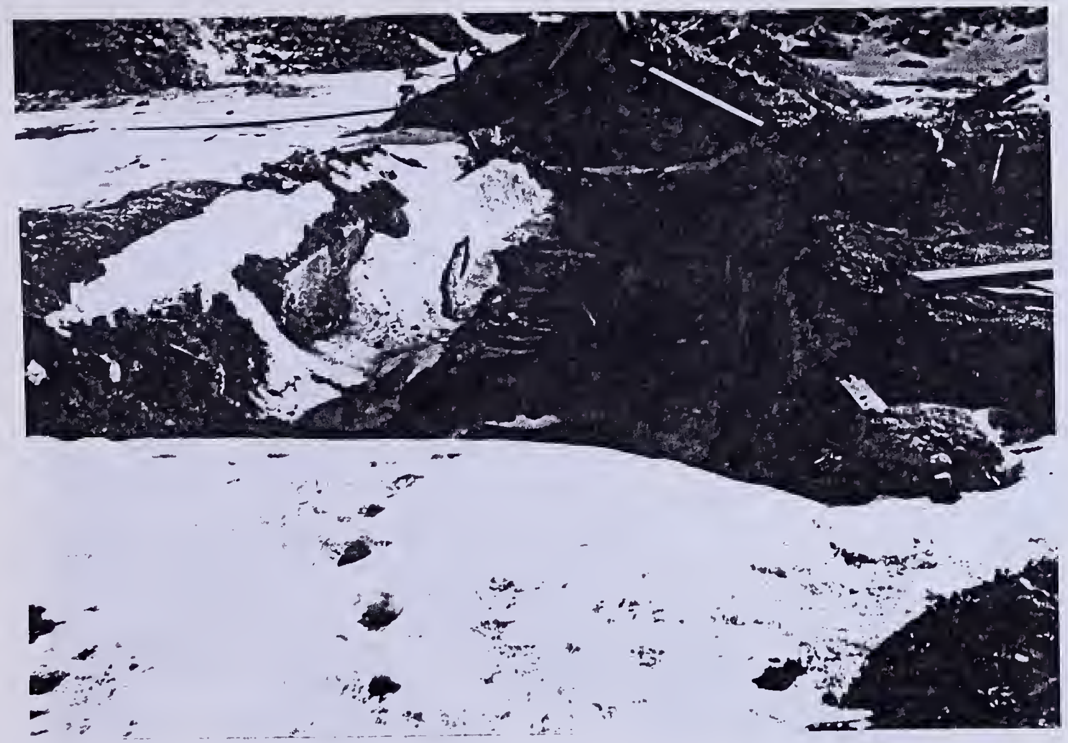
MAP INDEX: I-27-59

MINE: Otisco

SUBJECT: Shaft Location - Recent Excavations

AERIAL PHOTO INDEX: P3-59

PAGE 1 OF 3



SAFETY HAZARD: There has been recent trenching with a dozer around the old hoist base. The shaft is located in upper portion of photo and is bulkheaded and covered with waste rock. The bulkhead will eventually fail causing severe subsidence. The area is open to the public.

HEALTH HAZARD: See pages 2 & 3

HEALTH HAZARD FACTOR:

SAFETY HAZARD FACTOR: 4

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Belmont

VIEW: Looking Northeasterly

PHOTO NEGATIVE INDEX: G8-2

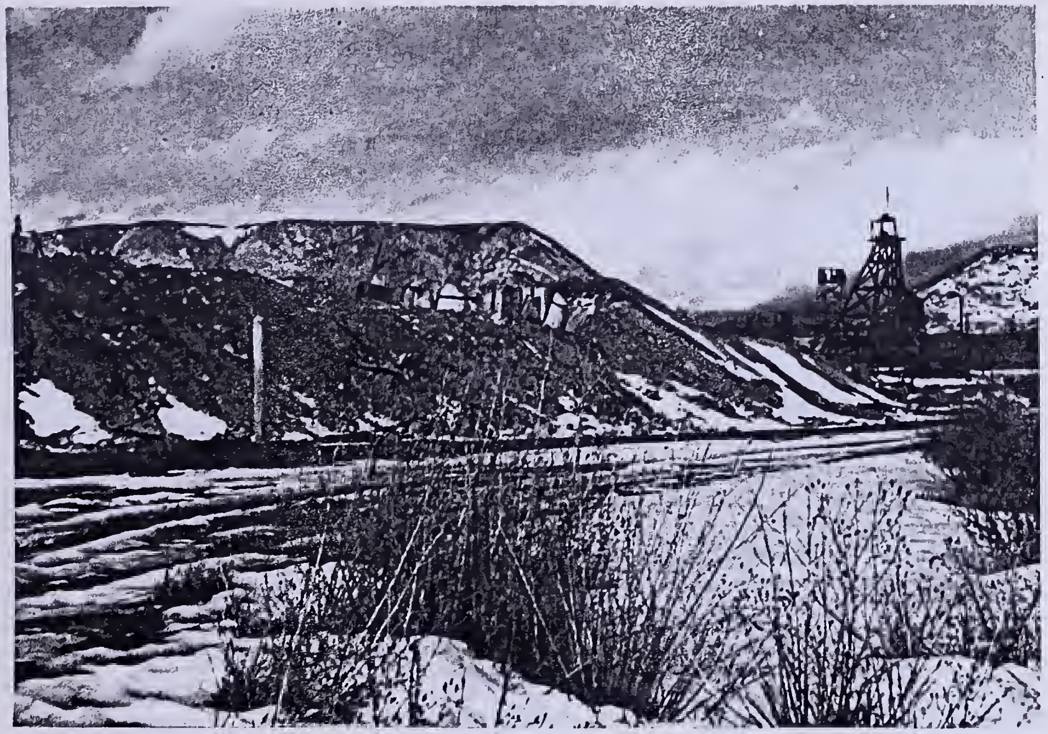
MAP INDEX: I-27-60

MINE: Otisco

SUBJECT: Waste Dump

AERIAL PHOTO INDEX: P3-60

PAGE 2 OF 3



SAFETY HAZARD: See page 1

HEALTH HAZARD: Re-worked waste dump is subject to wind blown dust and water erosion. The acid composition of the spoil piles prevents vegetation.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR:

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Belmont

VIEW: Looking Easterly

PHOTO NEGATIVE INDEX: G8-3

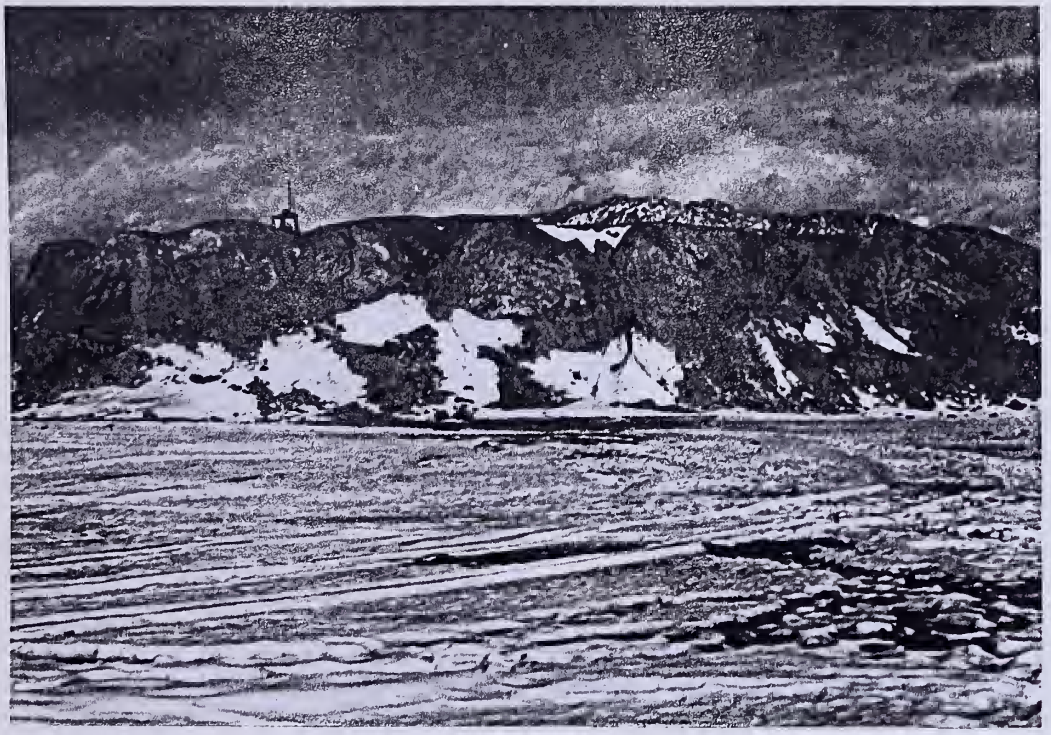
MAP INDEX: I-27-61

MINE: Otisco

SUBJECT: Waste Dump after Mining

AERIAL PHOTO INDEX: P3-61

PAGE 3 OF 3



SAFETY HAZARD: See page 1

HEALTH HAZARD: Recent excavation of the waste dump has loosened the crust and allowed the pile to be subject to heavy dust erosion.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR:

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Belmont

VIEW: Looking Northeasterly

PHOTO NEGATIVE INDEX: G8-10

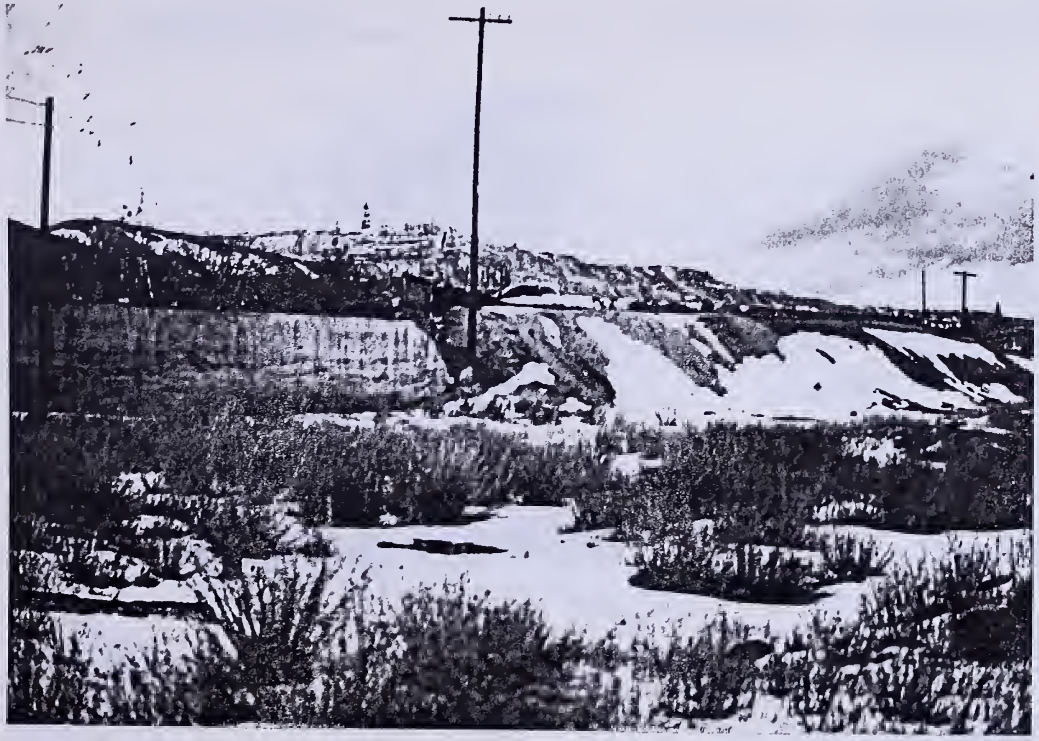
MAP INDEX: I-27-54

MINE: New England

SUBJECT: Waste Dump

AERIAL PHOTO INDEX: P6-54

PAGE 1 OF 1



SAFETY HAZARD: Shaft probably filled

HEALTH HAZARD: Barren waste pile subject to dusting. Dump material is acidic preventing vegetation.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 0

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Belmont

VIEW: Looking Westerly

PHOTO NEGATIVE INDEX: G8-9

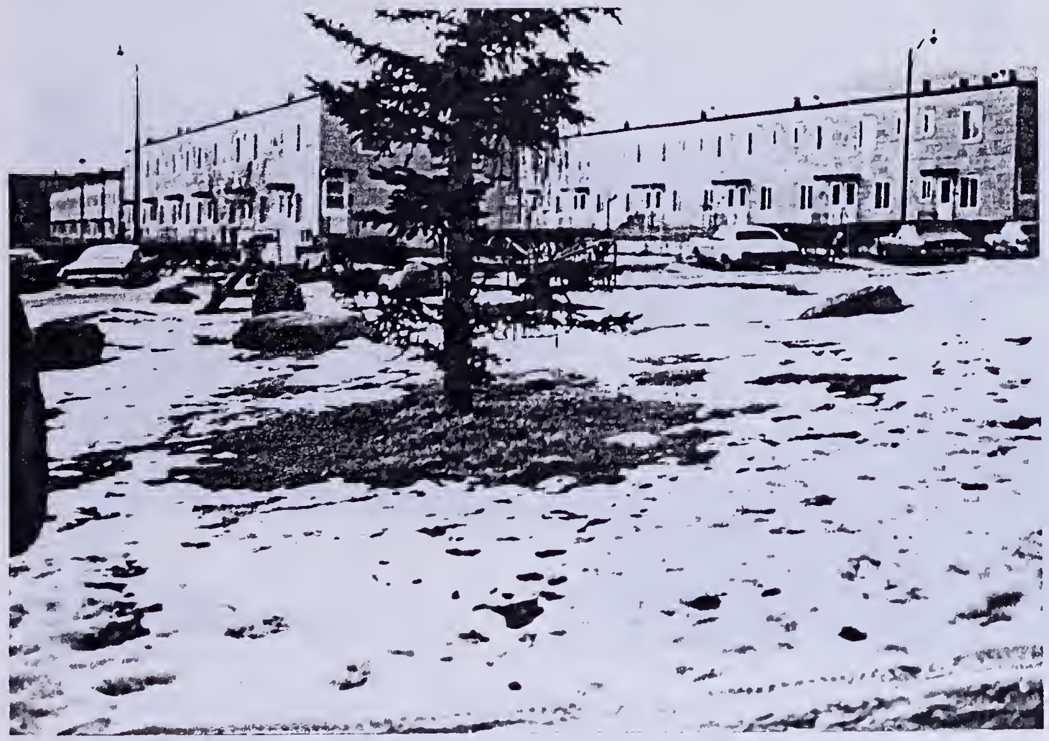
MAP INDEX: I-27-55

MINE: Syndicate

SUBJECT: Shaft Location

AERIAL PHOTO INDEX: P6-55

PAGE 1 OF 1



SAFETY HAZARD: The syndicate shaft is located within the small park and play yard. Subsidence could develop in the area if the shaft has not been properly filled. The shaft is small and shallow, likely not more than 200 feet deep. It, in all probability, has caved a hundred or more feet below the surface and choked off with very little or no opening below the choke. The subsidence created by the shaft failure has been filled in the past but a continued subsidence, although not extremely hazardous, can be expected.

HEALTH HAZARD: N/A

HEALTH HAZARD FACTOR:

SAFETY HAZARD FACTOR: 2

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Belmont

VIEW: Looking Easterly

PHOTO NEGATIVE INDEX: G8-6

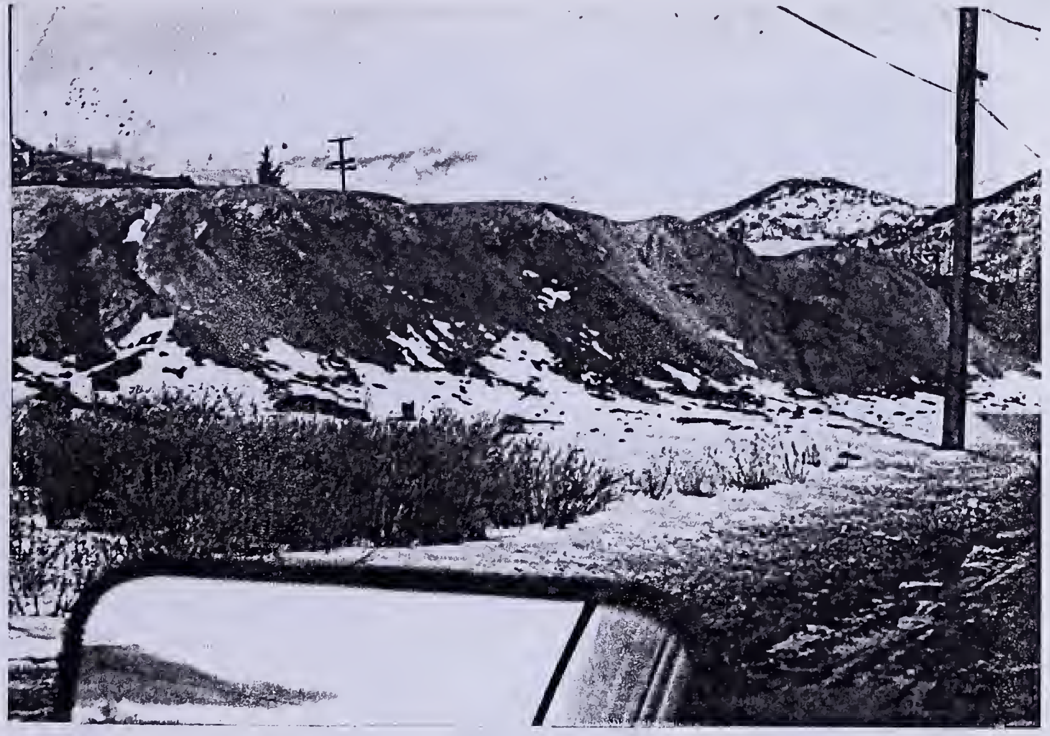
MAP INDEX: I-27-56

MINE: Veronica

SUBJECT: Waste Dump

AERIAL PHOTO INDEX: P6-56

PAGE 1 OF 3



SAFETY HAZARD: N/A

HEALTH HAZARD: Barren, unattended spoil piles subject to wind erosion. Acid composition prevents vegetation.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 0

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Belmont

VIEW: Looking Easterly

PHOTO NEGATIVE INDEX: G8-7

MAP INDEX: I-27-57

MINE: Veronica

SUBJECT: Shaft Position

AERIAL PHOTO INDEX: P6-57

PAGE 2 OF 3

SAFETY HAZARD: Although there is no record of shaft depth, from the appearances of the waste dump, it could be up to 300 feet deep. In all probability the shaft is caved 200 feet or more below the surface. The subsidence created on surface was filled, although probably not too well. Future subsidence, although not serious, will cause the surface to slump but no openings can be expected.

HEALTH HAZARD: Same as page 1

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 2

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Belmont

VIEW: Looking Southerly

PHOTO NEGATIVE INDEX: G15 - 10

G15-10

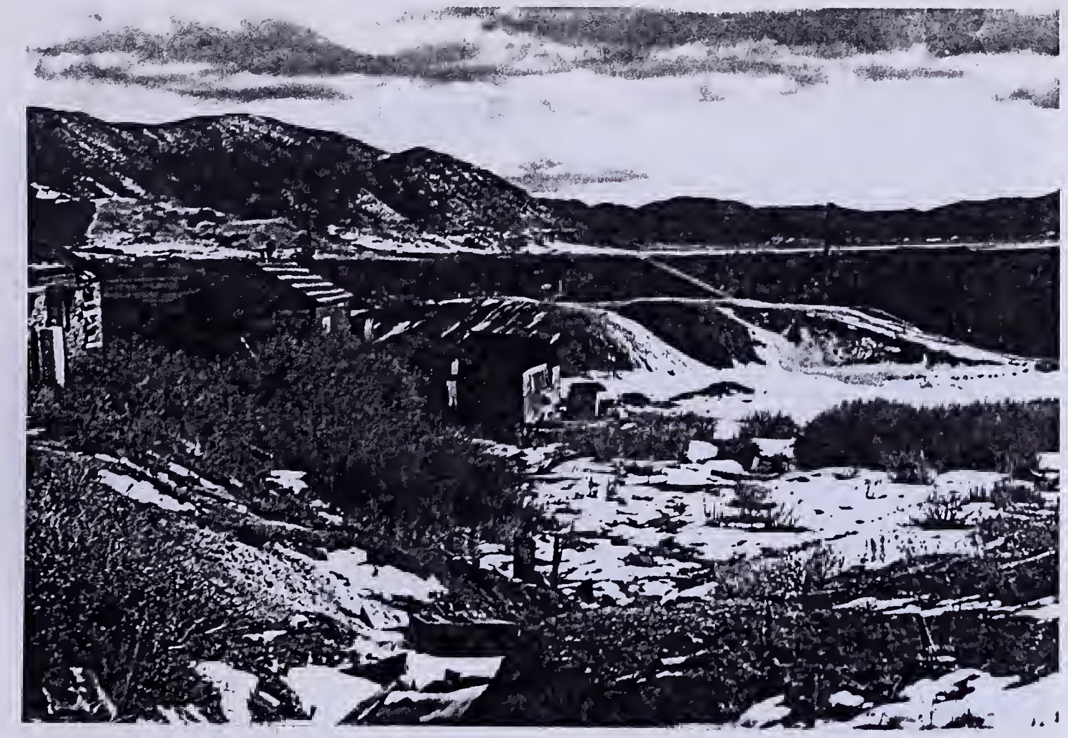
MAP INDEX: I-27-58

MINE: Veronica

SUBJECT: Waste Dump and Residences

AERIAL PHOTO INDEX: P6-58

PAGE 3 OF 3



SAFETY HAZARD: N/A

HEALTH HAZARD: Waste dump is hazardous and is in close proximity to residences. Dusting from the spoil pile of acidic nature is a health hazard.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR:

MISCELLANEOUS COMMENTS:

AREA: Belmont

VIEW: Looking Northwesterly

PHOTO NEGATIVE INDEX: G7-22

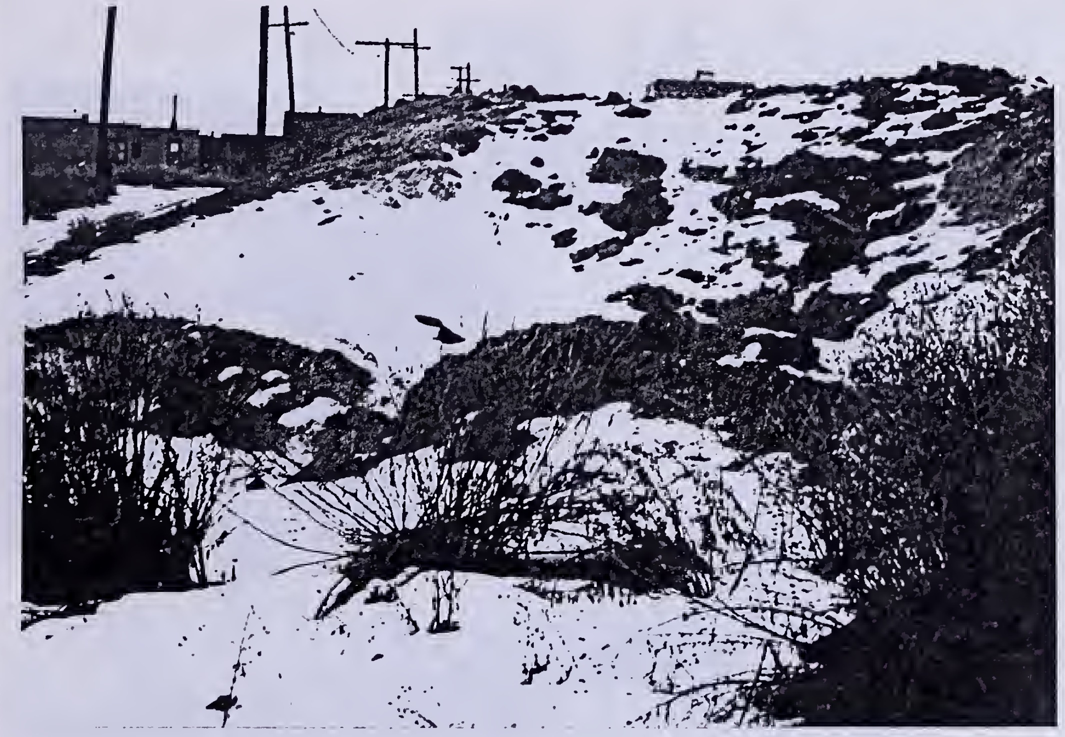
MAP INDEX: I-27-62

MINE: Hoy

SUBJECT: Recent Subsidence

AERIAL PHOTO INDEX: P6-62

PAGE 1 OF 1



SAFETY HAZARD: The 200 foot shaft shows evidence of recent subsidence. Probably a surface or sub-surface bulkhead failed.

HEALTH HAZARD: N/A

HEALTH HAZARD FACTOR:

SAFETY HAZARD FACTOR: 3

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Belmont

VIEW: Looking Northerly

PHOTO NEGATIVE INDEX: G7-23

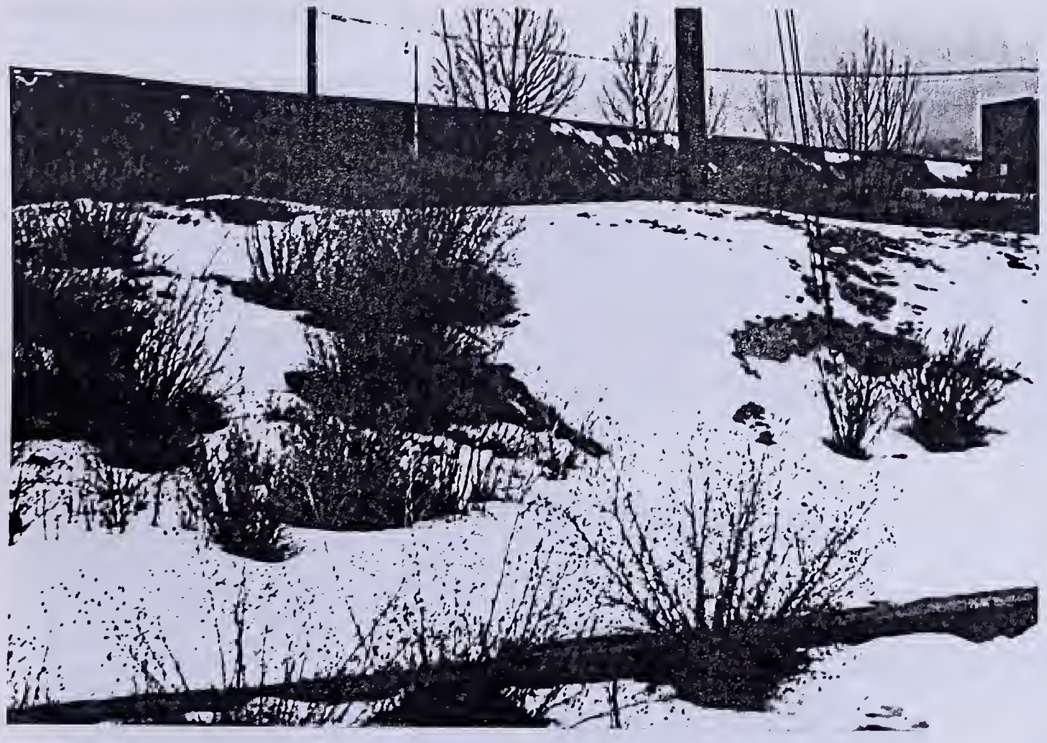
MAP INDEX: I-27-63

MINE: Burns

SUBJECT: Shaft Location

AERIAL PHOTO INDEX: P6-63

PAGE 1 OF 1



SAFETY HAZARD: The shaft location in center foreground appears to be filled.

HEALTH HAZARD:

HEALTH HAZARD FACTOR:

SAFETY HAZARD FACTOR: 0

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Belmont

VIEW: Looking Northeasterly

PHOTO NEGATIVE INDEX: G15-11

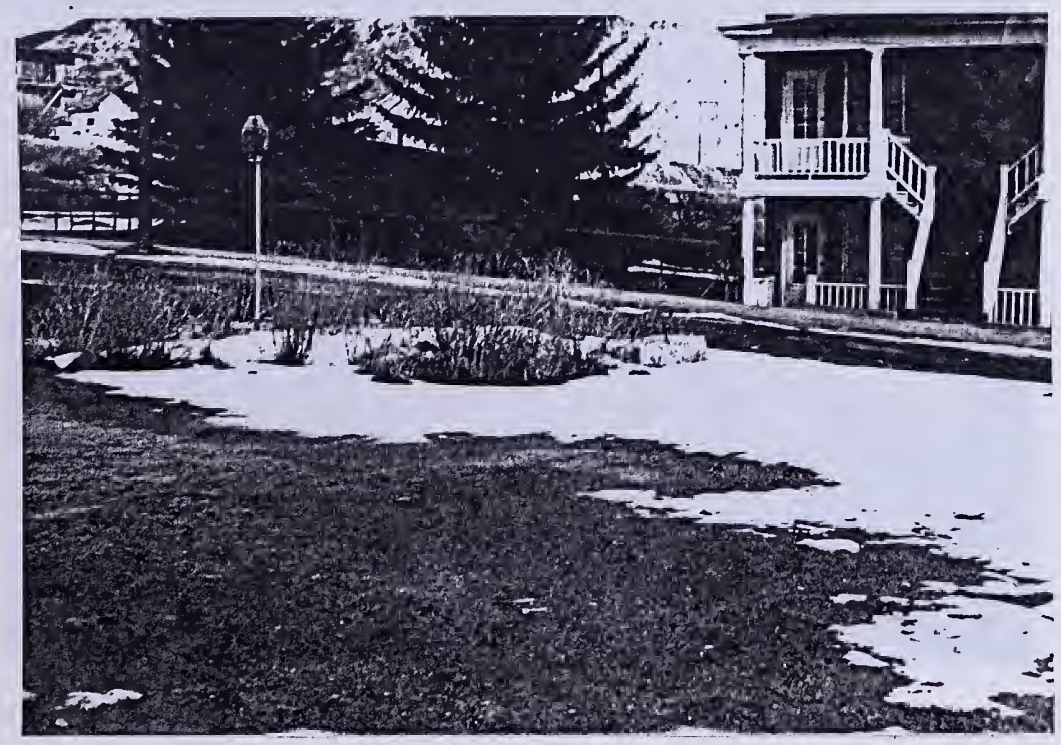
MAP INDEX: I-27-64

MINE: Ramsdell

SUBJECT: Shaft Location & Engine Base

AERIAL PHOTO INDEX: P6-64

PAGE 1 **OF** 2



SAFETY HAZARD: The Ramsdell shaft is 300 feet deep and the surface over the shaft does not indicate that it was filled. Most likely the shaft is bulkheaded and if so can produce a hazardous situation if the bulkhead should fail. Due to the depth of only 300 feet a safety hazard factor of 2.5 is applied. Shafts 100 to 300 feet deep usually cave about 100 to 150 feet below surface which chokes off the remaining opening below to total depth. Usually slumping only appears on the surface over the shaft and does not give the extremely hazardous openings created by larger and deeper shafts.

HEALTH HAZARD:

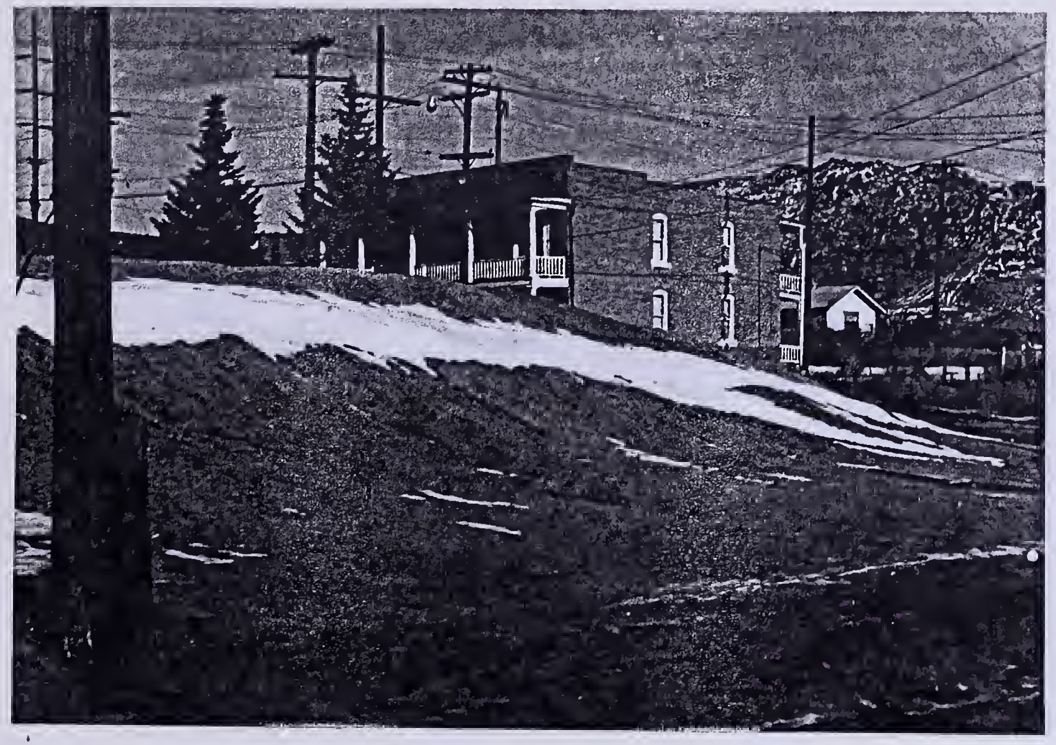
HEALTH HAZARD FACTOR: See page 2

SAFETY HAZARD FACTOR: 2.5

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Belmont
VIEW: Looking Northeasterly
PHOTO NEGATIVE INDEX: G11-7
MAP INDEX: I-27-65
MINE: Ramsdell
SUBJECT: Waste Dump
AERIAL PHOTO INDEX: P6-65
PAGE 2 OF 2



HEALTH HAZARD: The waste dump has been sloped which has loosened the oxidized crust and created a dusting condition. The spoil pile is acid and dust from the pile is a hazard particularly to residences as close as shown in the photo.

SAFETY HAZARD: See page 1

HEALTH HAZARD FACTOR: 3
SAFETY HAZARD FACTOR:
MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Belmont

VIEW: Looking Westerly

PHOTO NEGATIVE INDEX: G14-14

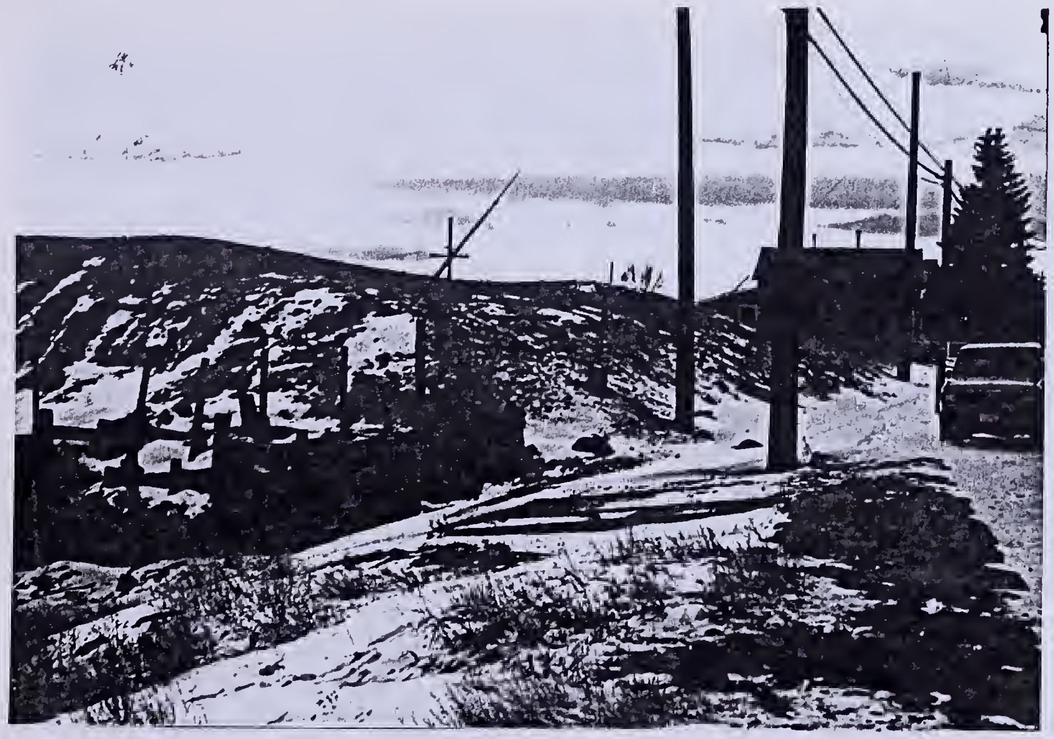
MAP INDEX: I-27-66

MINE: Hesperus

SUBJECT: Hesperus Dump & Shaft Area

AERIAL PHOTO INDEX: P6-66

PAGE 1 OF 3



SAFETY HAZARD: The surface area indicates that the shaft may have been filled, although the large waste dump implies a deep shaft. No record of the depth has been found. The shaft could have been filled on top of a bulkhead, if so, it could be a hazard in the future. The area is adjacent to residences and entirely open to the public.

HEALTH HAZARD: The waste spoil pile is slightly acidic and vulnerable to dusting from wind. Due to its location adjacent to residences and along Park Street, it creates a health hazard to the public.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 3

MISCELLANEOUS COMMENTS:

AREA: Belmont

VIEW: Looking West

PHOTO NEGATIVE INDEX: G7-14

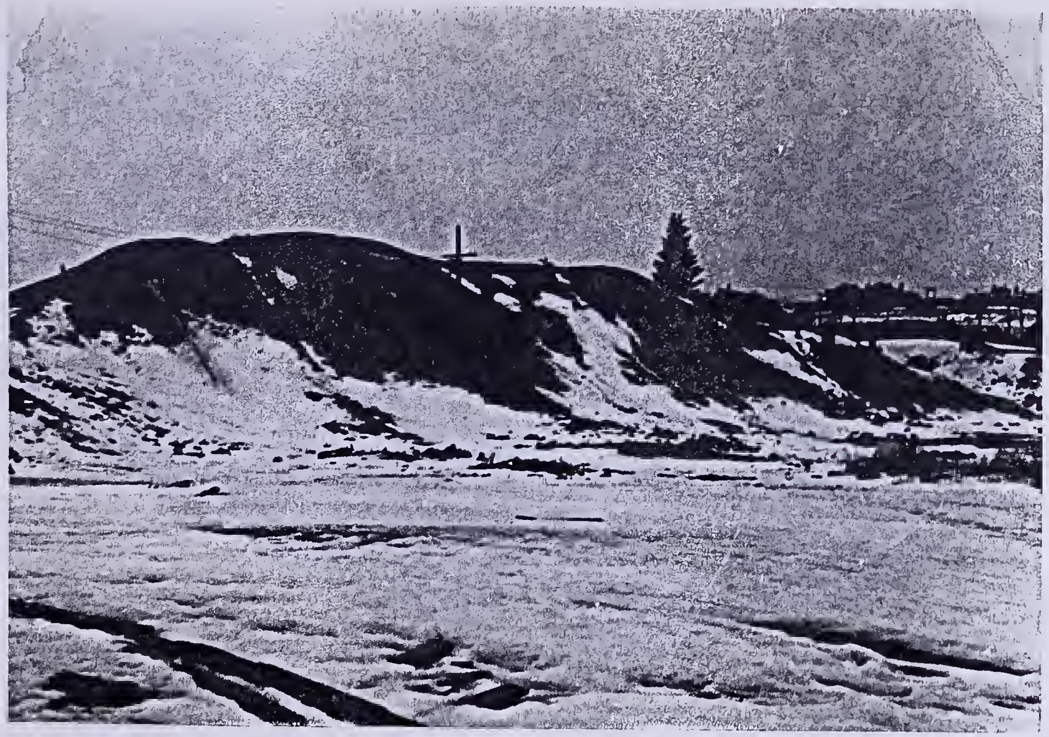
MAP INDEX: I-27-67

MINE: Hesperus

SUBJECT: Waste Dump

AERIAL PHOTO INDEX: P6-67

PAGE 2 OF 3



HEALTH HAZARD: See page 1

Health hazard from acid dust blown from the waste pile.

SAFETY HAZARD: See page 1

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR:

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Belmont

VIEW: Looking Northeasterly

PHOTO NEGATIVE INDEX: G7-16

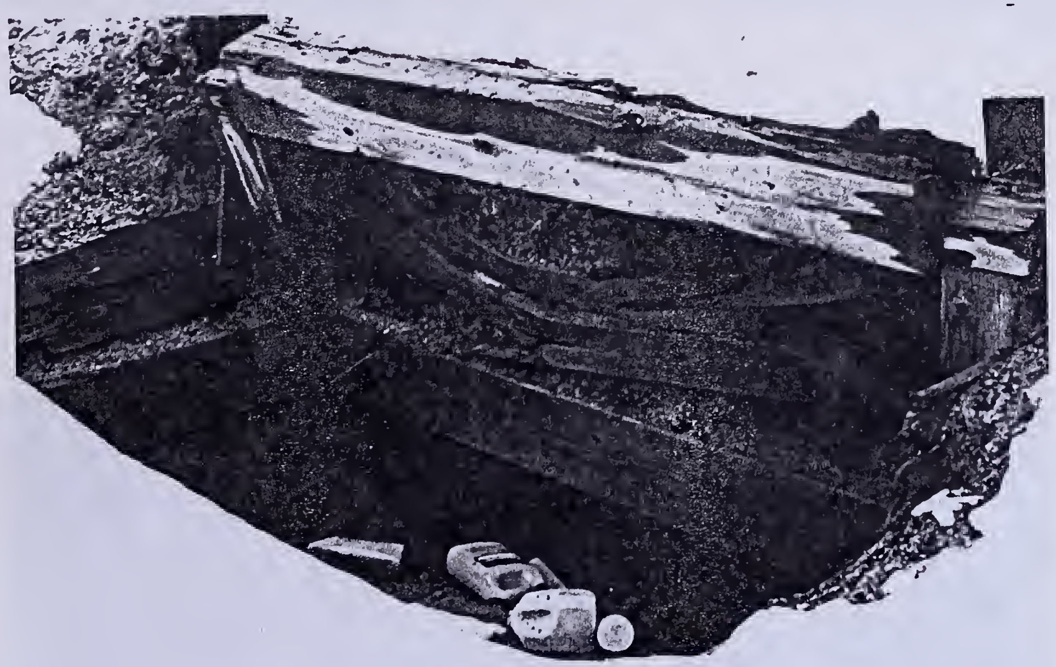
MAP INDEX: I-27-68

MINE: Hesperus (area)

SUBJECT: Old Shaft

AERIAL PHOTO INDEX: P6-68

PAGE 3 OF 3



SAFETY HAZARD: This is an old shaft in the Hesperus area, depth unknown, name unknown. From all appearances there is a bulkhead a few feet below the collar. Only a small waste dump is adjacent to the shaft, therefore the shaft probably is not deep. The shaft should be filled and a mound of waste material placed over it to protect from further subsidence.

HEALTH HAZARD: N/A

HEALTH HAZARD FACTOR:

SAFETY HAZARD FACTOR: 2

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Belmont

VIEW: Looking Northwesterly

PHOTO NEGATIVE INDEX: G11-2

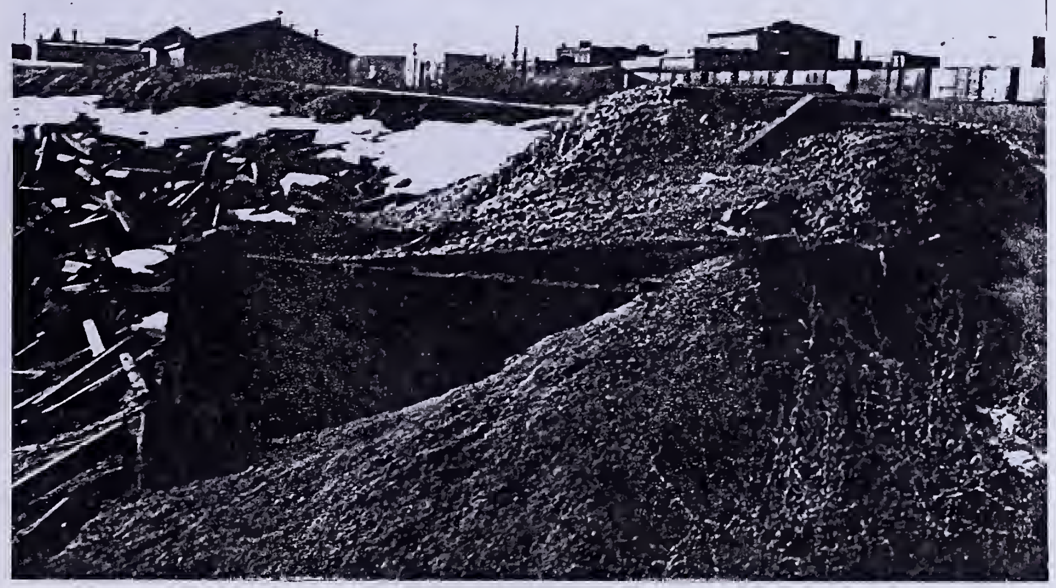
MAP INDEX: I-27-69

MINE: Childe Harold #2

SUBJECT: Shaft Collar

AERIAL PHOTO INDEX: P3-69

PAGE 1 OF 3



SAFETY HAZARD: The shaft, 100 to 200 feet deep, has been covered and filled with waste material several times in the past but has continued to subside. The shaft appears to have never been bulkheaded and subsidence can take place again. The surface is unlikely to open up, therefore is not considered to be severely hazardous. The shaft is small and in all probability is nearly closed by caving but will continue to slump.

HEALTH HAZARD: The shaft area is used as a scrapwood disposal area by a nearby resident. The crust on the dump has been broken recently, probably from machinery used in the wood cutting operation, making the dump susceptible to wind blown slightly acid material.

HEALTH HAZARD FACTOR: 1

SAFETY HAZARD FACTOR: 2

MISCELLANEOUS COMMENTS:

AREA: Belmont

VIEW: Looking Southeasterly

PHOTO NEGATIVE INDEX: G11-3

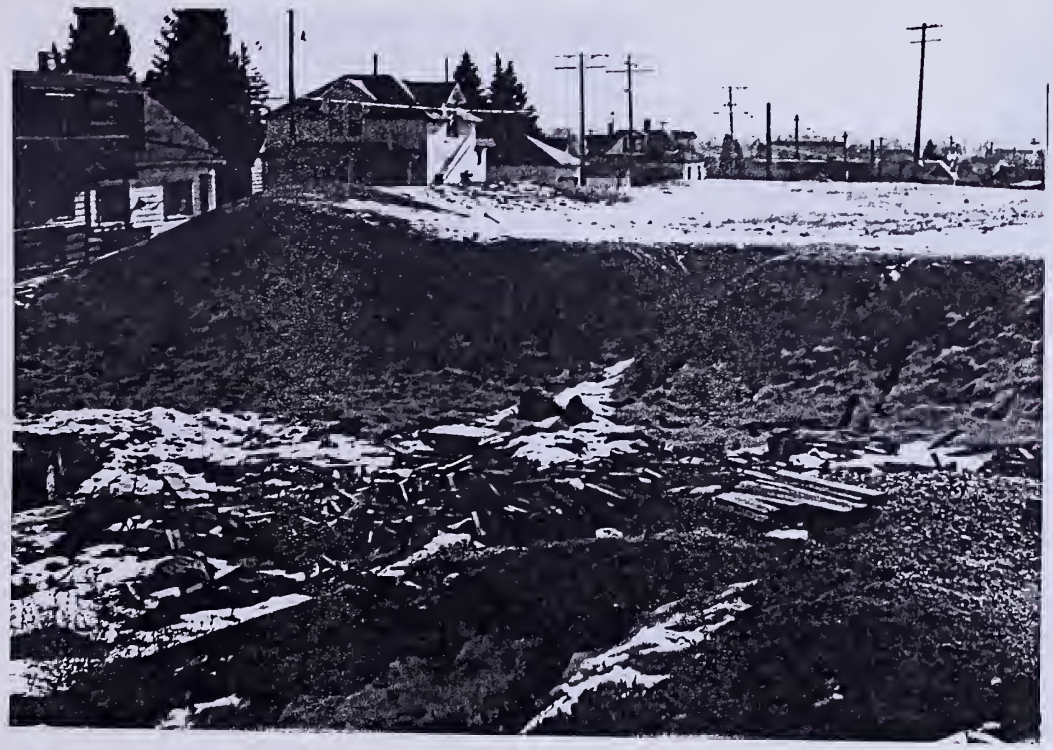
MAP INDEX: I-27-70

MINE: Childe Harold #2

SUBJECT: Waste Dump

AERIAL PHOTO INDEX: P3-70

PAGE 2 OF 3



HEALTH HAZARD: See page 1

SAFETY HAZARD: See page 1

HEALTH HAZARD FACTOR: 1

SAFETY HAZARD FACTOR: 2

MISCELLANEOUS COMMENTS:

AREA: Belmont

VIEW: Looking Southeasterly

PHOTO NEGATIVE INDEX: G7-7

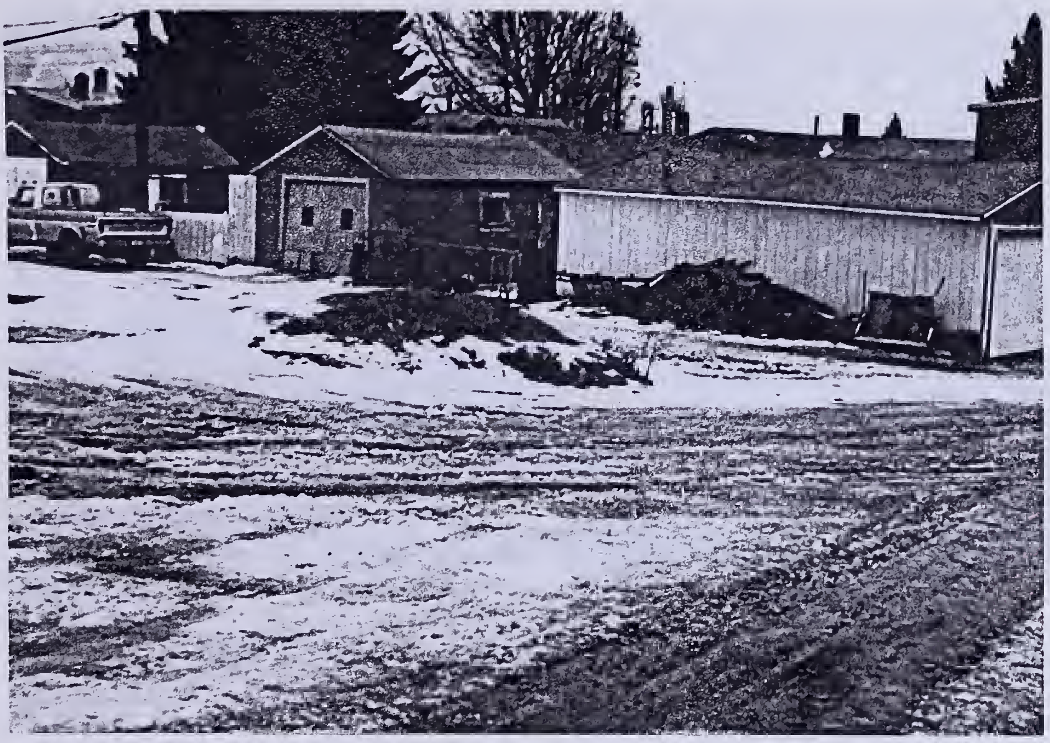
MAP INDEX: I-27-71

MINE: Childe Harold #2
(Green Copper)

SUBJECT: Small filled Shaft

AERIAL PHOTO INDEX: P3-71

PAGE 3 OF 3



SAFETY HAZARD: This shaft was filled many years ago. The mound in the photo is the remanents of the filling operation.

HEALTH HAZARD: N/A

HEALTH HAZARD FACTOR:

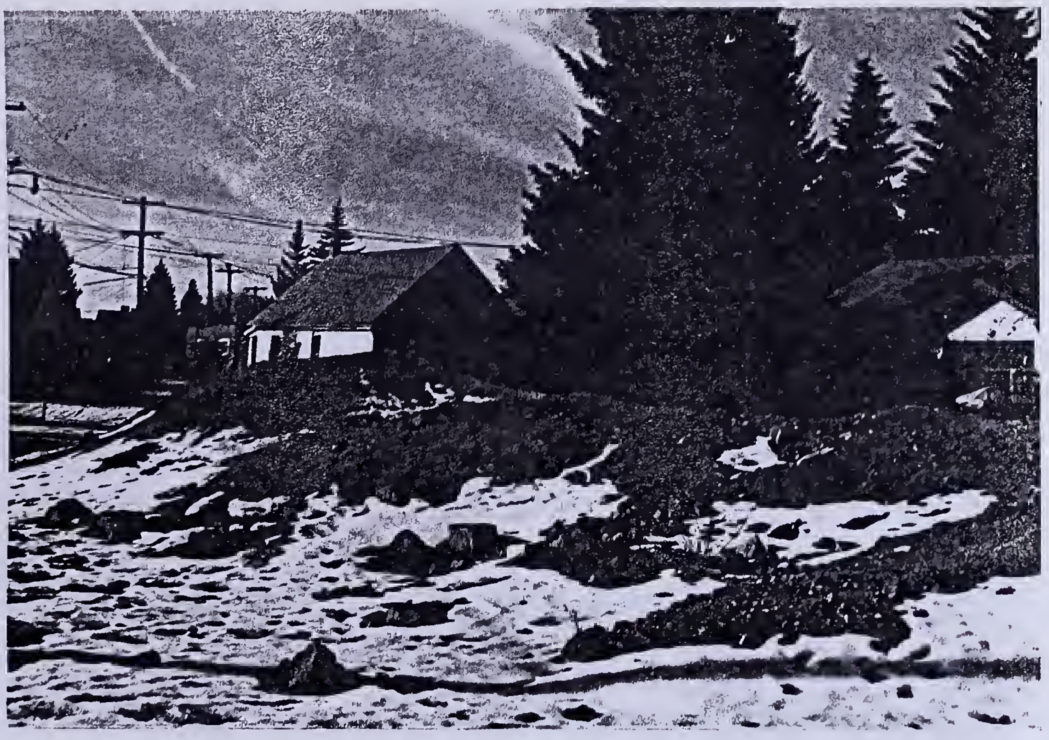
SAFETY HAZARD FACTOR: 0

MISCELLANEOUS COMMENTS:

AREA: Belmont
VIEW: Looking Westerly
PHOTO NEGATIVE INDEX: G11-4
MAP INDEX: I-27-72

MINE: Heany
SUBJECT: Waste Dump
AERIAL PHOTO INDEX: P3-72

PAGE 1 OF 2



SAFETY HAZARD: Shaft filled

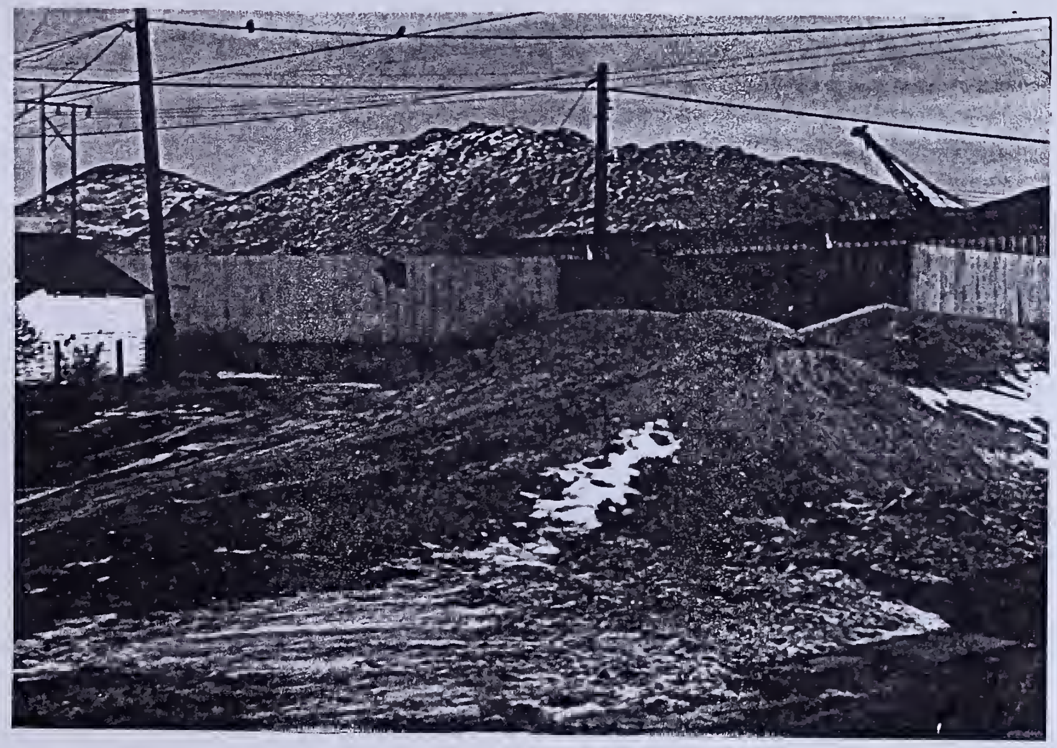
HEALTH HAZARD: The waste dump has recently been opened, creating a dust condition. The dump is acid and will not support vegetation.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 0

MISCELLANEOUS COMMENTS:

AREA: Belmont
VIEW: Looking Northerly
PHOTO NEGATIVE INDEX: G11-5
MAP INDEX: I-27-73
MINE: Heany
SUBJECT: Waste Dump
AERIAL PHOTO INDEX: P3-73
PAGE 2 OF 2



SAFETY HAZARD: Shaft filled

HEALTH HAZARD: See page 1

HEALTH HAZARD FACTOR: 2
SAFETY HAZARD FACTOR: 0
MISCELLANEOUS COMMENTS:

PIPER & ASSOCIATES, INC.
Mining Industry Consultants
2940 Edwards St., Butte, Montana 59701
(406) 494-5369 or (406) 723-8905

MT. CON-STEWARD AREA

This area encompasses all that portion of Metropolitan Butte between Broadway Street on the south to the Mt. Con on the north and from the Berkeley Mining Permit area on the east to Montana Street on the west. All areas disturbed by mining as well as all shaft openings were examined and assessed for health and safety hazards.

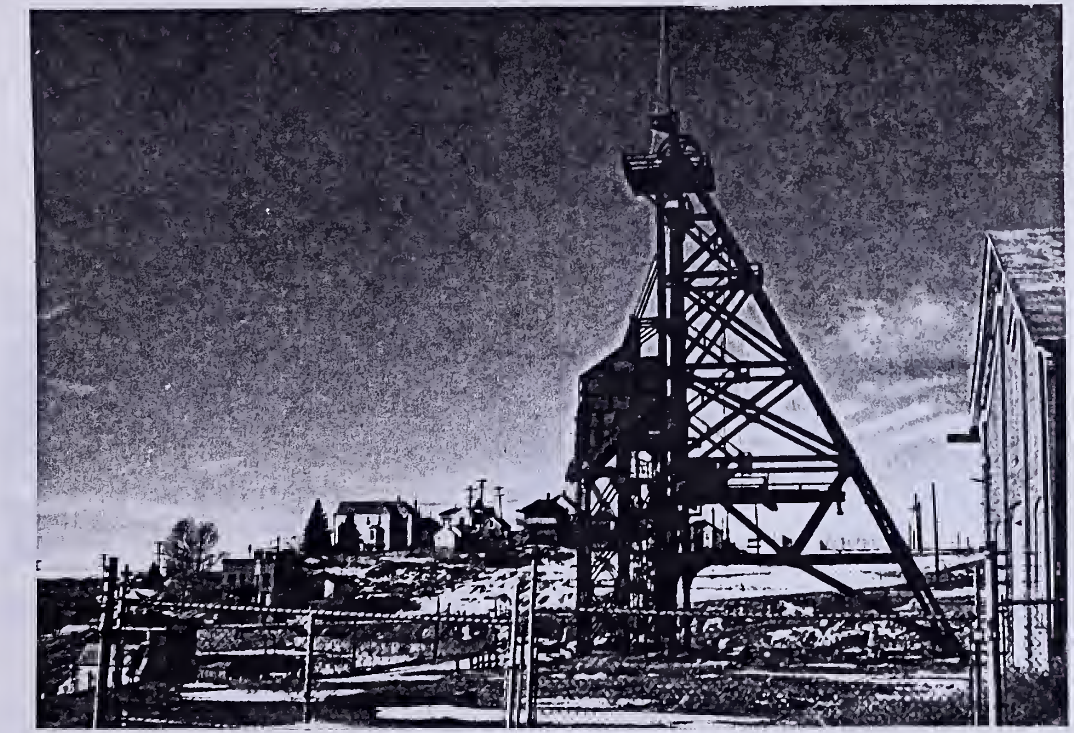
Three mine shafts, the Mt. Con, Steward, and Buffalo, were considered to be the most hazardous for safety reasons. The Mt. Con and Steward shafts, both in excess of 4500 feet in depth, are a serious threat to future safety. Although the Buffalo is somewhat less in depth, 2200 feet, it is a serious safety hazard.

The Clear Grit and Original #6 shafts, although relatively shallow as compared to the Mt. Con and Steward, are vulnerable to caving. Being located in a heavily populated area and not protected by fencing, they present a serious threat to the safety of the public.

The Parrott is considered the next most hazardous site. Although inside the main mine fence it is accessible to anyone wishing to enter the yard. The shaft is not bulkheaded and the opening is only protected with a locked wooden housing.

Numerous other smaller shafts in the area considered a safety hazard have been examined in detail.

AREA: Mt. Con - Steward
VIEW: Looking Westerly
PHOTO NEGATIVE INDEX: G15-23
MAP INDEX: M-23-94
MINE: Original
SUBJECT: Shaft & Headframe
AERIAL PHOTO INDEX: P6-94
PAGE 1 OF 1



SAFETY HAZARD: The original shaft is 3900 feet deep and located in a heavily populated area of Metropoliton Butte. A wooden bulkhead topped with concrete rests on timber sets about 40 feet below the surface. The shaft was filled to the surface with waste rock on top of the bulkhead. The wood will rot beneath the concrete and the bulkhead will eventually fail letting the collar of the shaft subside. Particularly due to its location in a heavily populated area the shaft is very hazardous.

HEALTH HAZARD: As the water rises in the underground mines, "bad air" will be forced up the shaft.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 5

MISCELLANEOUS COMMENTS:

G14-7

AREA: Mt. Con - Steward

VIEW: Looking Southerly

PHOTO NEGATIVE INDEX: G14-7

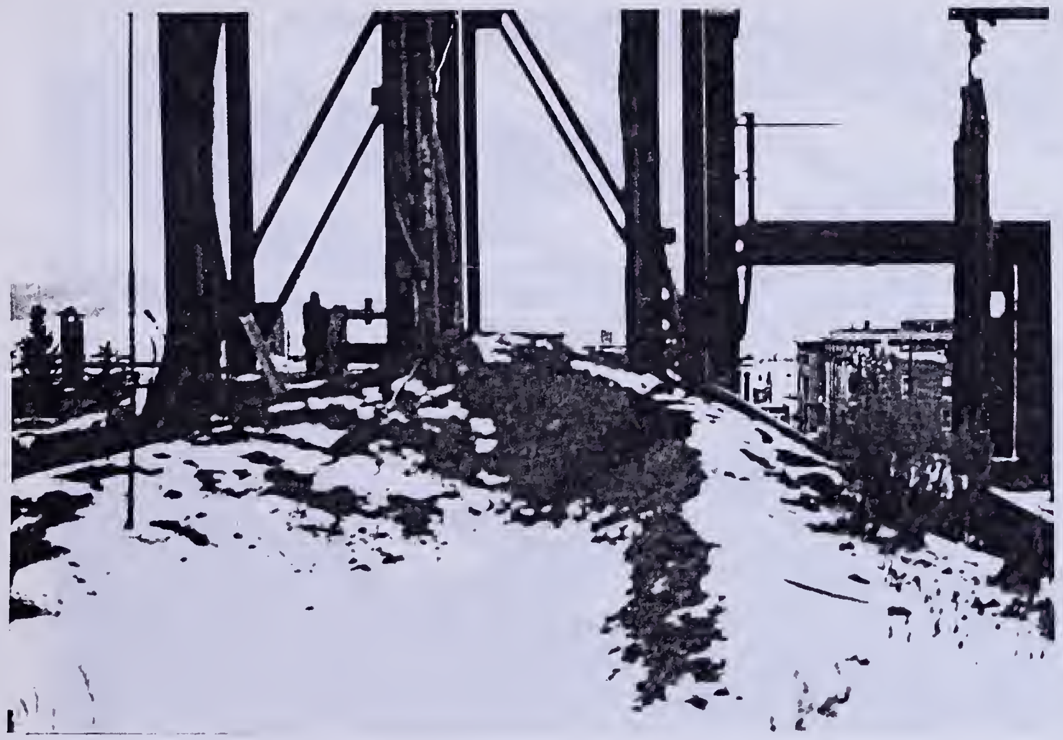
MAP INDEX: M-23-95

MINE: Original

SUBJECT: Shaft & Headframe

AERIAL PHOTO INDEX: P6-95

PAGE 2 OF 2



SAFETY HAZARD: The photo shows the waste rock that was placed in the shaft to the surface.

See page 1 for hazardous condition.

HEALTH HAZARD: Same as page 1

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 5

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Mt. Con - Steward

VIEW: Looking Easterly

PHOTO NEGATIVE INDEX: G15-19

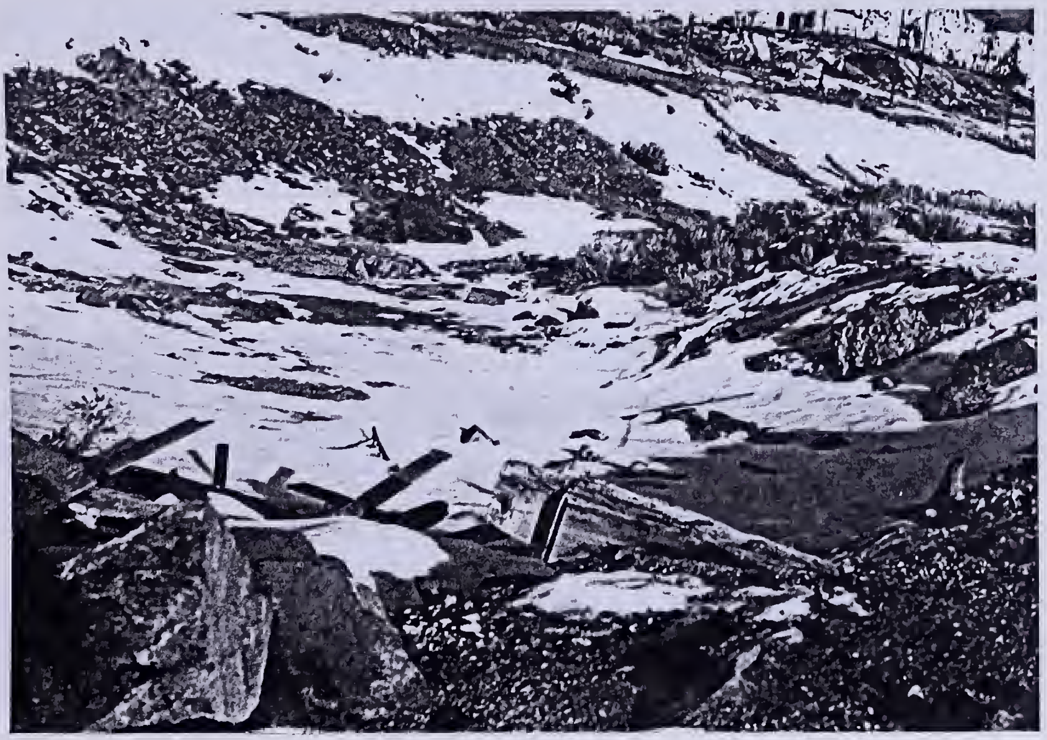
MAP INDEX: M-23-92

MINE: Poulin

SUBJECT: Shaft Location

AERIAL PHOTO INDEX: P6-92

PAGE 1 OF 2



SAFETY HAZARD: The Poulin shaft shown in the photo was filled many years ago and there is no evidence of subsidence at present.

HEALTH HAZARD: N/A

HEALTH HAZARD FACTOR:

SAFETY HAZARD FACTOR: 0

MISCELLANEOUS COMMENTS:

AREA: Mt. Con - Steward

VIEW: Looking Northwesterly

PHOTO NEGATIVE INDEX: G16-14

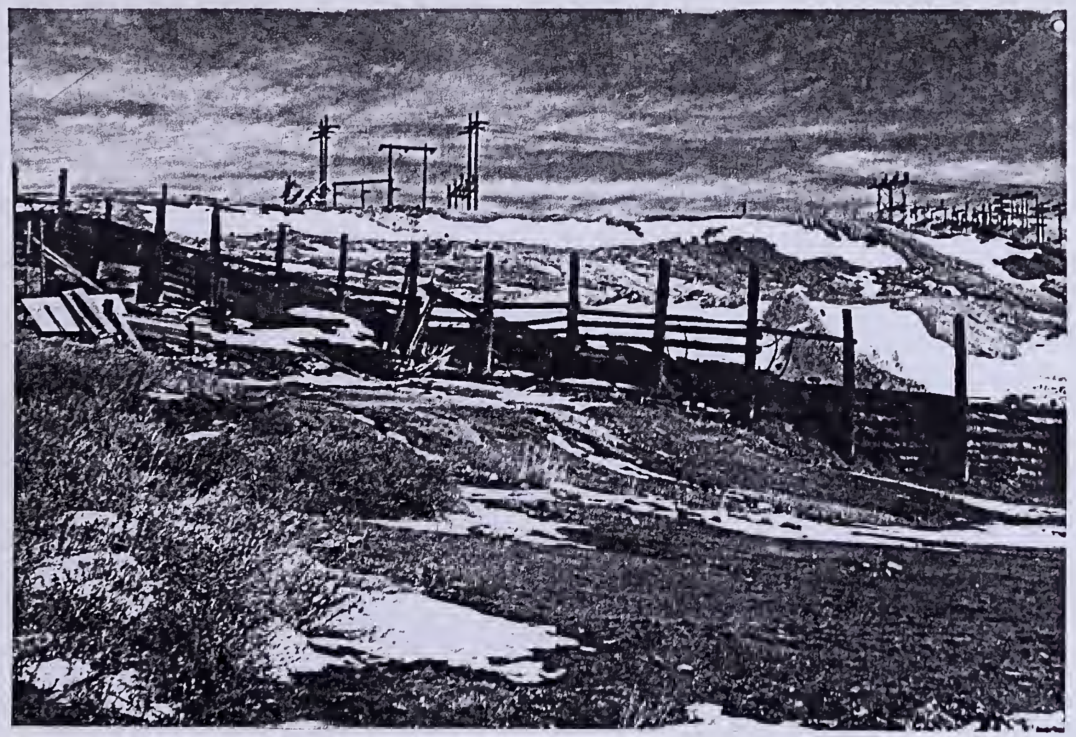
MAP INDEX: M-23-93

MINE: Poulin

SUBJECT: Waste Dump

AERIAL PHOTO INDEX: P6-93

PAGE 2 OF 2



HEALTH HAZARD: The dump has been reworked some in past years breaking the oxidized crust and allowing a water erosion and wind dusting condition.

SAFETY HAZARD: There is a small hazard to children playing around the old waste dump crib work. The waste dump is located near several residences.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 1

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Mt. Con - Steward

VIEW: Looking westerly

PHOTO NEGATIVE INDEX: G16-8

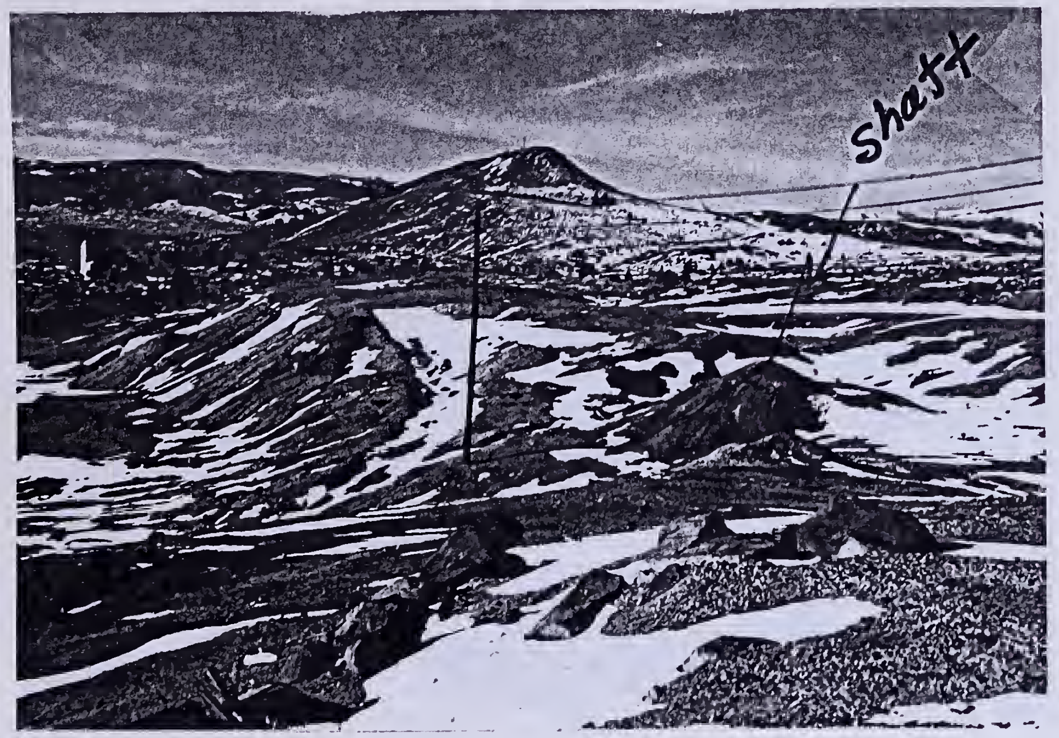
MAP INDEX: M-27-106

MINE: Estella

SUBJECT: Shaft Collar Location

AERIAL PHOTO INDEX: P6-106

PAGE 1 OF 2



SAFETY HAZARD: The shaft was filled many years ago and shows no evidence of subsidence.

HEALTH HAZARD: The waste dump is adjacent to a residential area and dusting from wind is a hazard. The dump is acid and does not support vegetation.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 0

MISCELLANEOUS COMMENTS:

AREA: Mt. Con - Steward

VIEW: Looking Northeasterly

PHOTO NEGATIVE INDEX: G15-18

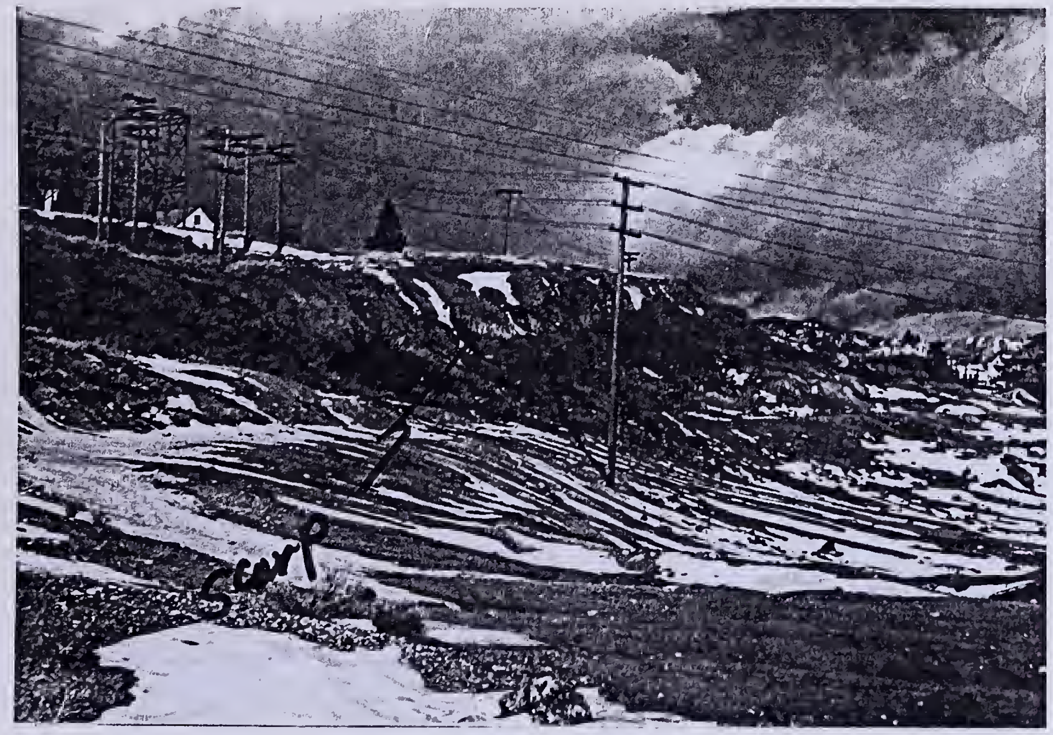
MAP INDEX: M-27-107

MINE: Estella Area

SUBJECT: Subsidence Scarp

AERIAL PHOTO INDEX: P6-107

PAGE 2 OF 2



SAFETY HAZARD: The 20 to 30 foot scarp along the foot wall of the Mt. Con vein is evidence of heavy subsidence in the area. There does not appear to be any recent movement.

HEALTH HAZARD: N/A

HEALTH HAZARD FACTOR:

SAFETY HAZARD FACTOR: 0

MISCELLANEOUS COMMENTS:

AREA: Mt. Con - Steward

VIEW: Looking Southeasterly

PHOTO NEGATIVE INDEX: G13-5

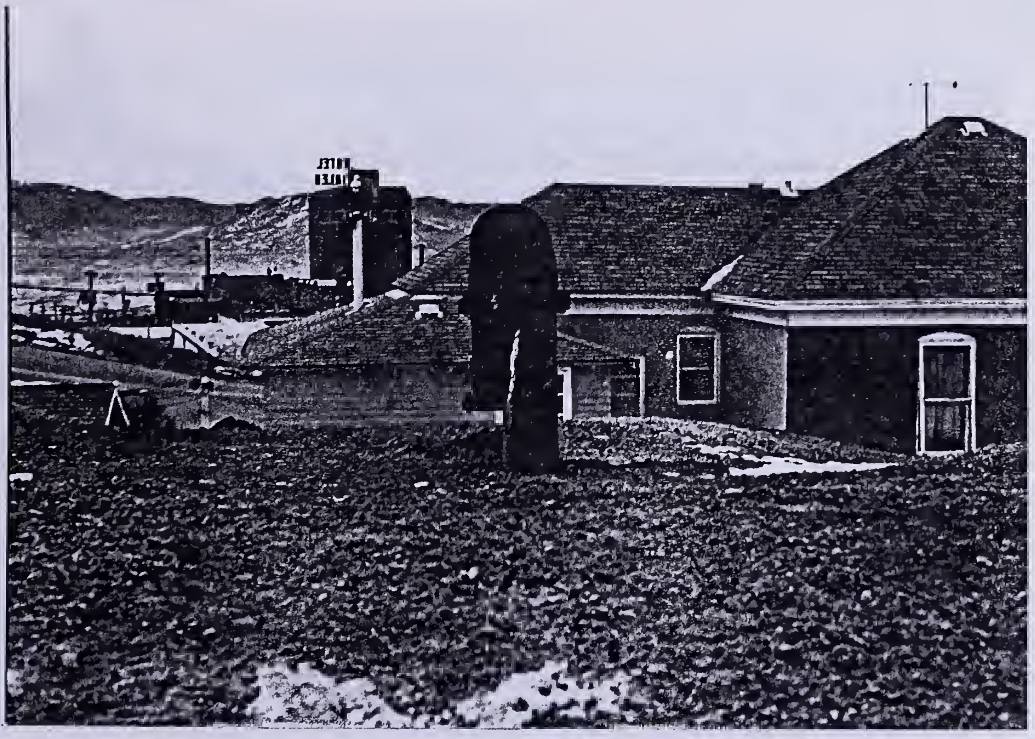
MAP INDEX: M-27-78

MINE: Original #6

SUBJECT: Shaft Location

AERIAL PHOTO INDEX: P6-78

PAGE 1 OF 2



SAFETY HAZARD: The shaft is 550 feet deep and to date shows no evidence of subsidence. The shaft is likely to have a wooden bulkhead a short distance below the surface, with a 12-inch breather pipe through the bulkhead. The bulkhead will eventually fail and allow the surface to subside. The unit is located in a heavily populated area adjacent to residences and is a serious future hazard.

HEALTH HAZARD: The waste spoil pile is located adjacent to residences and is likely to be quite acid. The surface crust is continually being broken by traffic & gouging from children at play allowing a dusting condition.

HEALTH HAZARD FACTOR: 2.5

SAFETY HAZARD FACTOR: 4

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Mt. Con - Steward

VIEW: Looking easterly

PHOTO NEGATIVE INDEX: G13-6

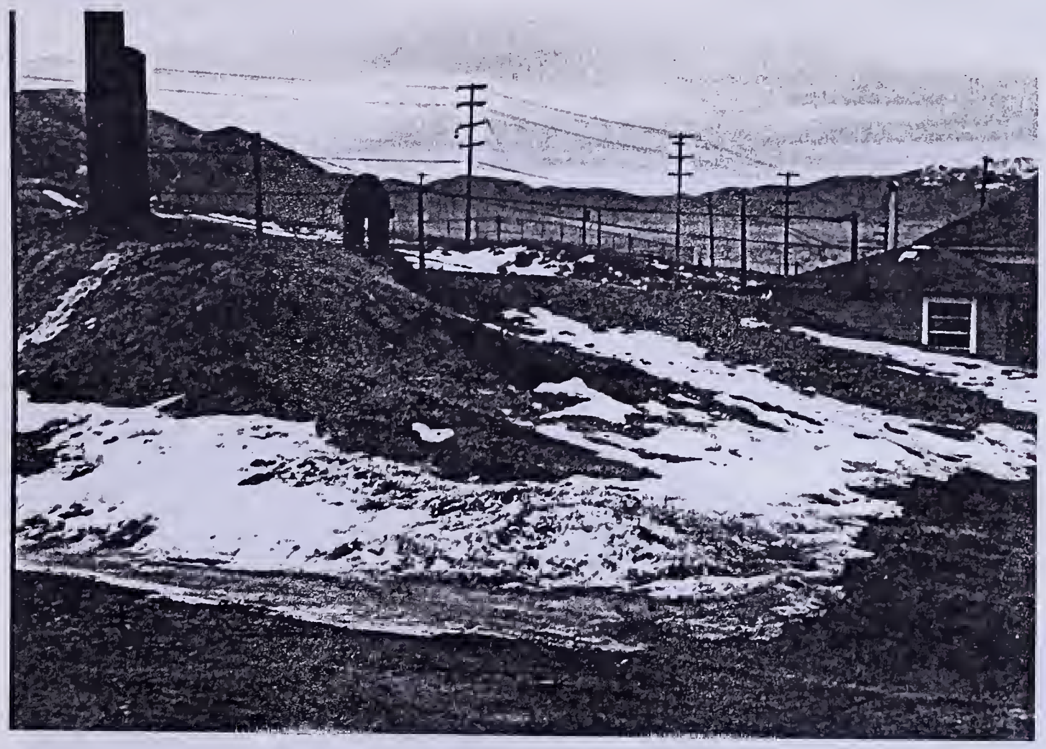
MAP INDEX: M-27-79

MINE: Original #6

SUBJECT: Waste Dump

AERIAL PHOTO INDEX: P6-79

PAGE 2 OF 2



SAFETY HAZARD: See page #1

HEALTH HAZARD: See page #1

HEALTH HAZARD FACTOR: 2.5

SAFETY HAZARD FACTOR: 4

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Mt. Con - Steward

VIEW: Looking Westerly

PHOTO NEGATIVE INDEX: G13-15

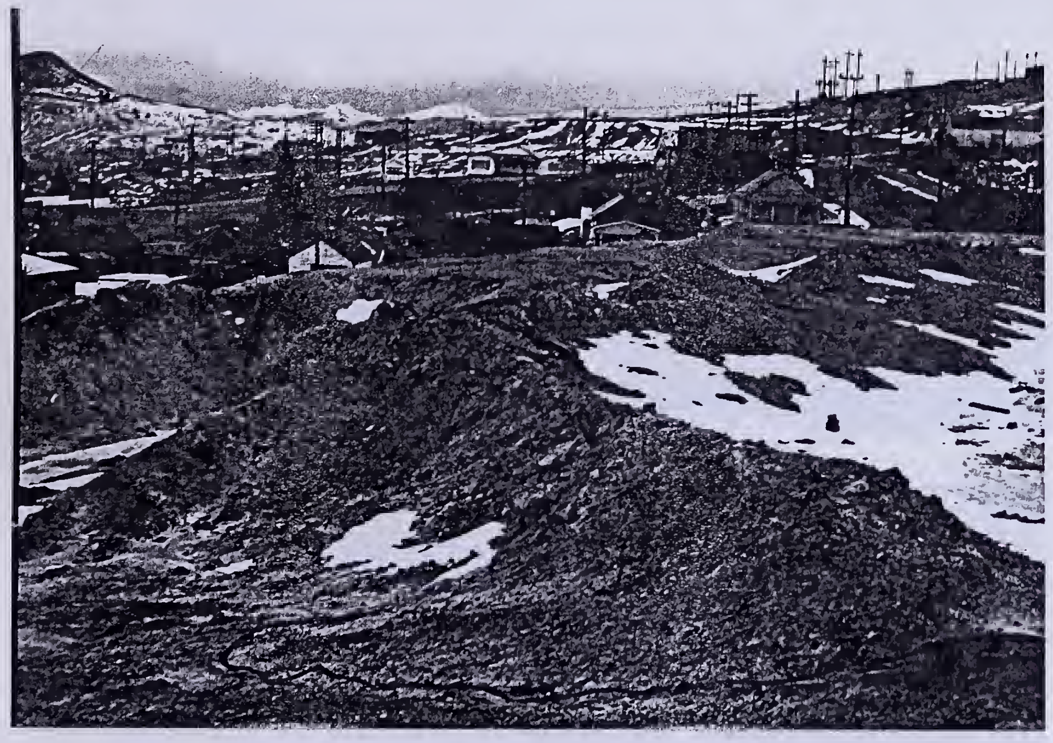
MAP INDEX: M-27-141

MINE: Little Mina

SUBJECT: Waste Dumps and Shaft Location

AERIAL PHOTO INDEX: P6-141

PAGE 1 OF 2



HEALTH HAZARD: The waste dump has been disturbed during recent years breaking the oxidized crust and allowing the dump to erode from water and wind. Due to its close proximity to residences it creates a dust hazard from erosion.

SAFETY HAZARD: The shaft is 1200 feet deep and was choked with timber a short distance below the collar and waste rock was placed on top to the surface. The shaft allegedly is not bulkheaded and will eventually cave. Due to its close proximity to residences and unprotected state it is a safety hazard.

HEALTH HAZARD FACTOR: 3

SAFETY HAZARD FACTOR: 4

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Mt. Con-Steward

VIEW: Looking Northerly

PHOTO NEGATIVE INDEX: G13-10

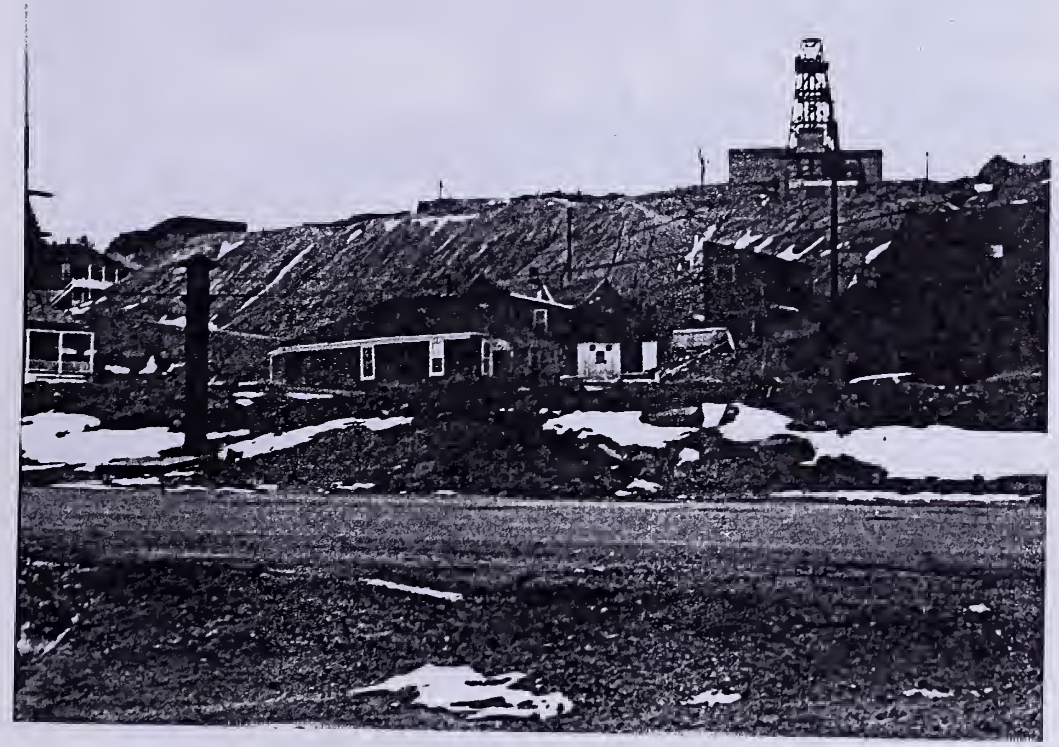
MAP INDEX: M-27-142

MINE: Little Mina

SUBJECT: Waste Dump & Shaft Location

AERIAL PHOTO INDEX: P6-142

PAGE 2 OF 2



HEALTH HAZARD: See page 1

SAFETY HAZARD: See page 1

HEALTH HAZARD FACTOR: 3

SAFETY HAZARD FACTOR: 4

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Mt. Con - Steward

VIEW: Looking Easterly

PHOTO NEGATIVE INDEX: G15-21

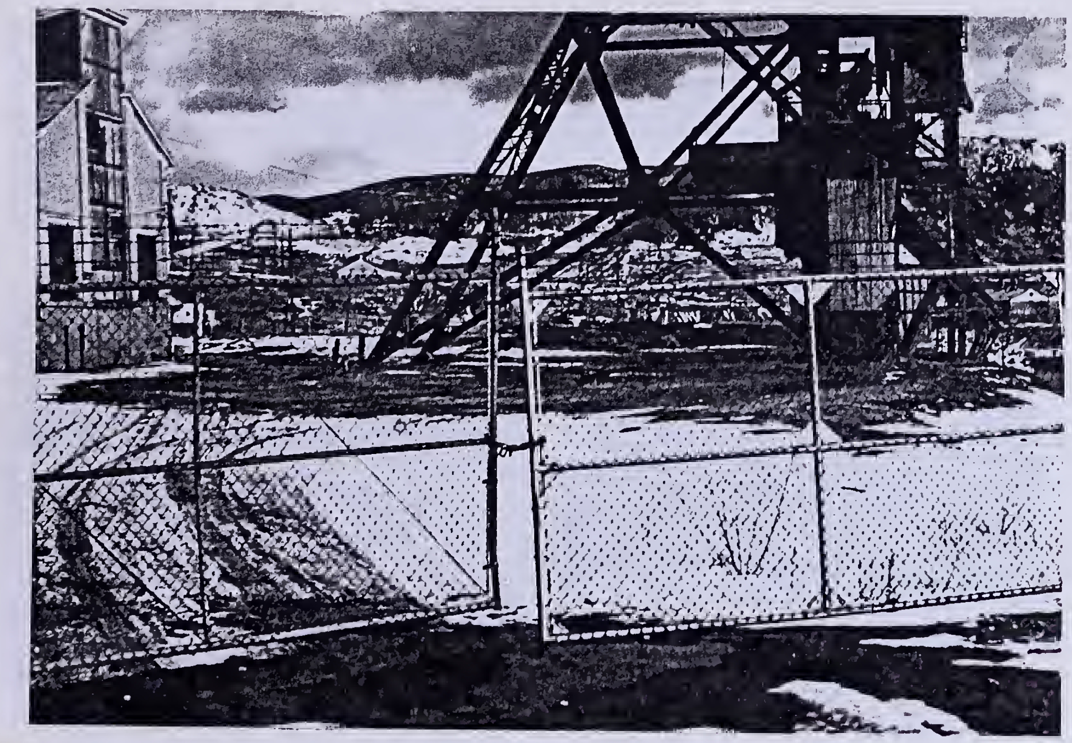
MAP INDEX: M-27-85

MINE: Steward

SUBJECT: Shaft & Headframe

AERIAL PHOTO INDEX: P3-85

PAGE 1 OF 3



SAFETY HAZARD: The Steward shaft is in close proximity to residences. The photo shows a cyclone fence which can easily be scaled and a person could also squeese thru the gate. Evidence was seen, from tracks in the yard, of children having gained entrance.

See page 2 for description of the shaft hazard.

HEALTH HAZARD: See page 2 for description of "bad air" hazard.

HEALTH HAZARD FACTOR: 3

SAFETY HAZARD FACTOR: 4

MISCELLANEOUS COMMENTS:

AREA: Mt. Con - Steward

VIEW: Looking Southerly

PHOTO NEGATIVE INDEX: G14-3

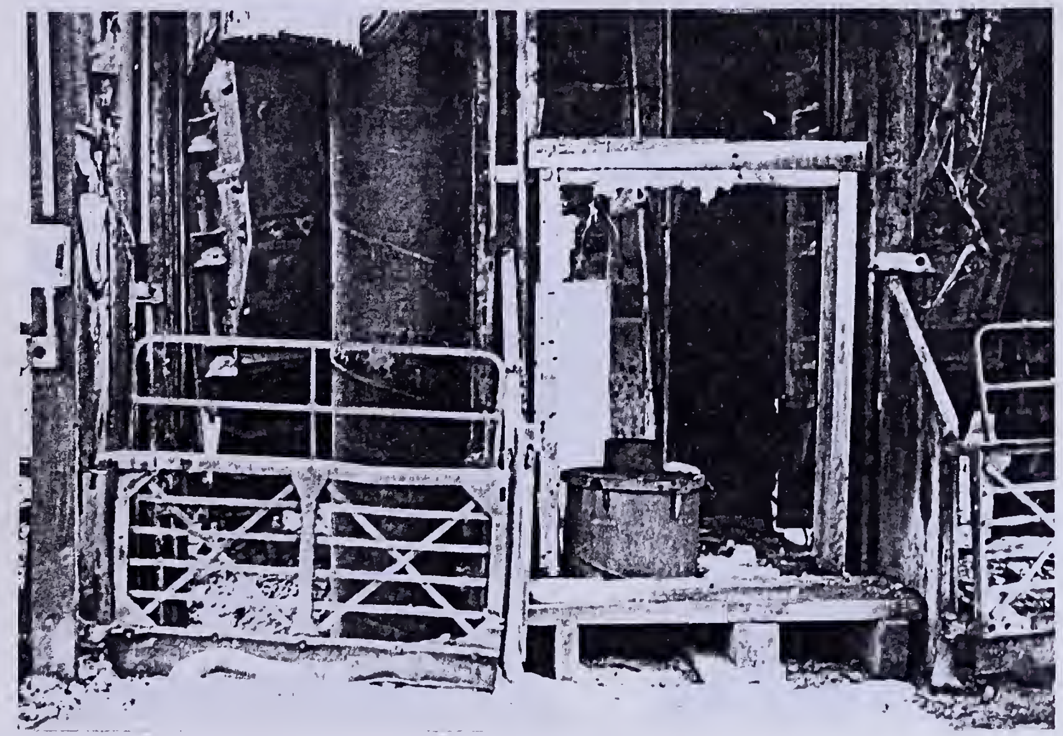
MAP INDEX: M-27-83

MINE: Steward

SUBJECT: Shaft

AERIAL PHOTO INDEX: P3-83

PAGE 2 OF 3



HEALTH HAZARD: Due to the rise of water in the underground workings, "bad air" will be forced up the shaft creating a health hazard.

SAFETY HAZARD: The shaft has been sealed with a wooden bulkhead about 40 ft. below the surface. Concrete has been poured on top of the bulkhead and waste rock placed on top of that. A 2-foot diameter vent tube was placed through the bulkhead in two compartments before the concrete was poured. The manway or west compartment is not filled with waste rock from the 40-foot level to surface and is only covered by 3-inch boards on the surface. The shaft bulkhead will eventually fail regardless of the concrete, due to the wooden support.

HEALTH HAZARD FACTOR: 3

SAFETY HAZARD FACTOR: 4

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Mt. Con - Steward

VIEW: Looking Southerly

PHOTO NEGATIVE INDEX: G14-2

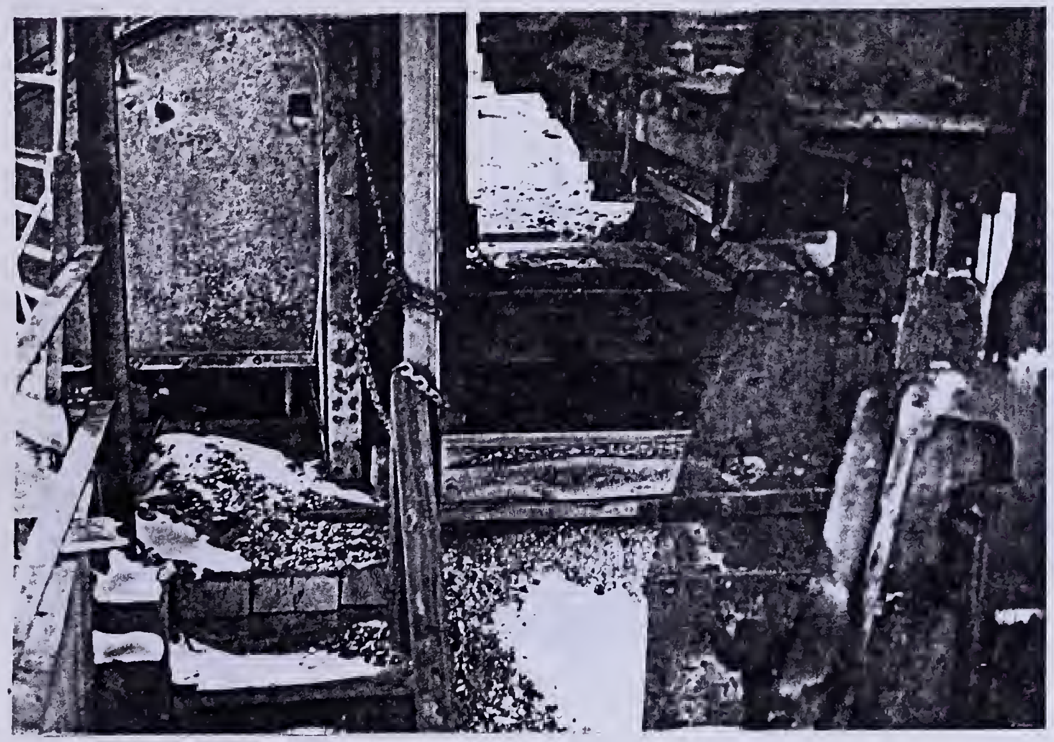
MAP INDEX: M-27-84

MINE: Steward

SUBJECT: Shaft

AERIAL PHOTO INDEX: P3-84

PAGE 3 OF 3



SAFETY HAZARD: See page 2

HEALTH HAZARD: See page 2

HEALTH HAZARD FACTOR: 3

SAFETY HAZARD FACTOR: 4

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Mt. Con - Steward

VIEW: Looking Easterly

PHOTO NEGATIVE INDEX: G13-8

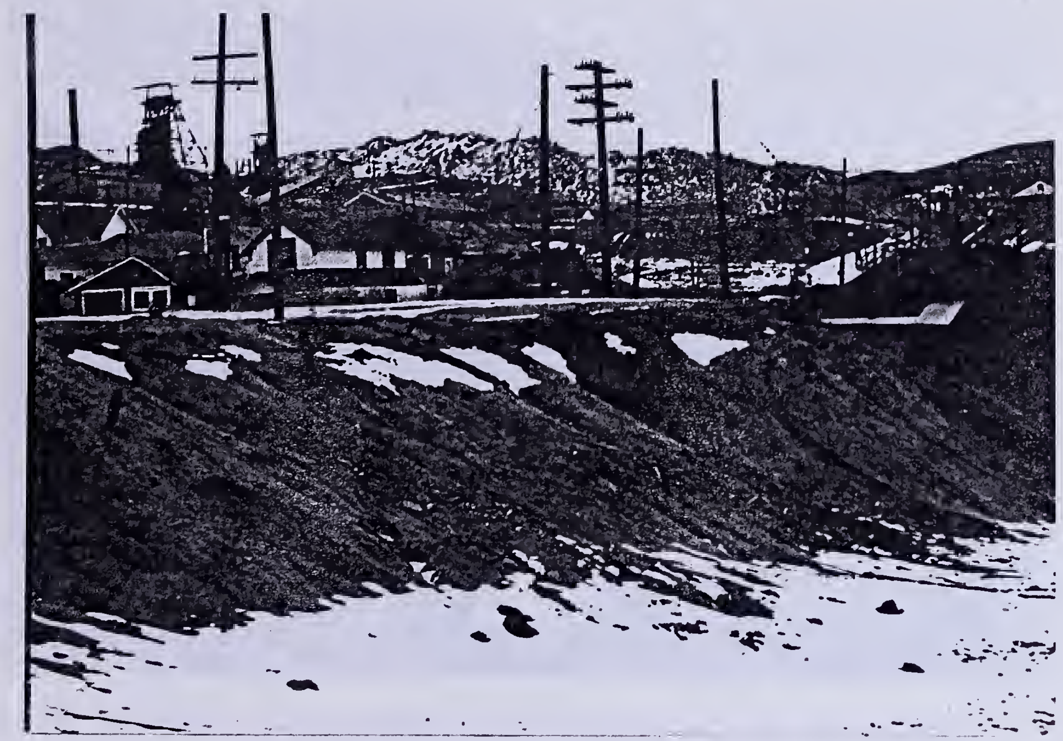
MAP INDEX: M-27-82

MINE: Benham

SUBJECT: Waste Dump & Shaft Location

AERIAL PHOTO INDEX: P6-82

PAGE 1 OF 1



SAFETY HAZARD: The top of the waste dump is now used as a playground. Due to the age of the shaft operation it is quite likely that the shaft is bulkheaded on or near the surface. There is no evidence that the shaft was ever filled. No material has been removed from the waste dump to indicate that the shaft was filled. Due to the facts of possible surface or near surface bulkhead, no evidence of shaft filling, and the close proximity to residences, the shaft is considered to be quite hazardous.

HEALTH HAZARD: The waste dump is adjacent to residences and causes a hazard from erosion and dusting.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 3

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Mt. Con - Steward VIEW: Looking Northeasterly

PHOTO NEGATIVE INDEX: G13-2

MAP INDEX: M-27-80

MINE: Morley, Baltic, Bellona, Blue Jay, Handlen, Thorton SUBJECT: Shaft Positions

AERIAL PHOTO INDEX: P6-80

PAGE 1 OF 2

HEALTH HAZARD: The area was covered with soil and seeded. Some erosion is taking place as shown in the photo on page 2. The debris is carried to the street, thus creating a bad dusting situation.

SAFETY HAZARD: The small shafts have all been filled when the reclamation project was performed in the area.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 0

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Mt. Con - Steward

VIEW: Looking Northerly

PHOTO NEGATIVE INDEX: G13-4

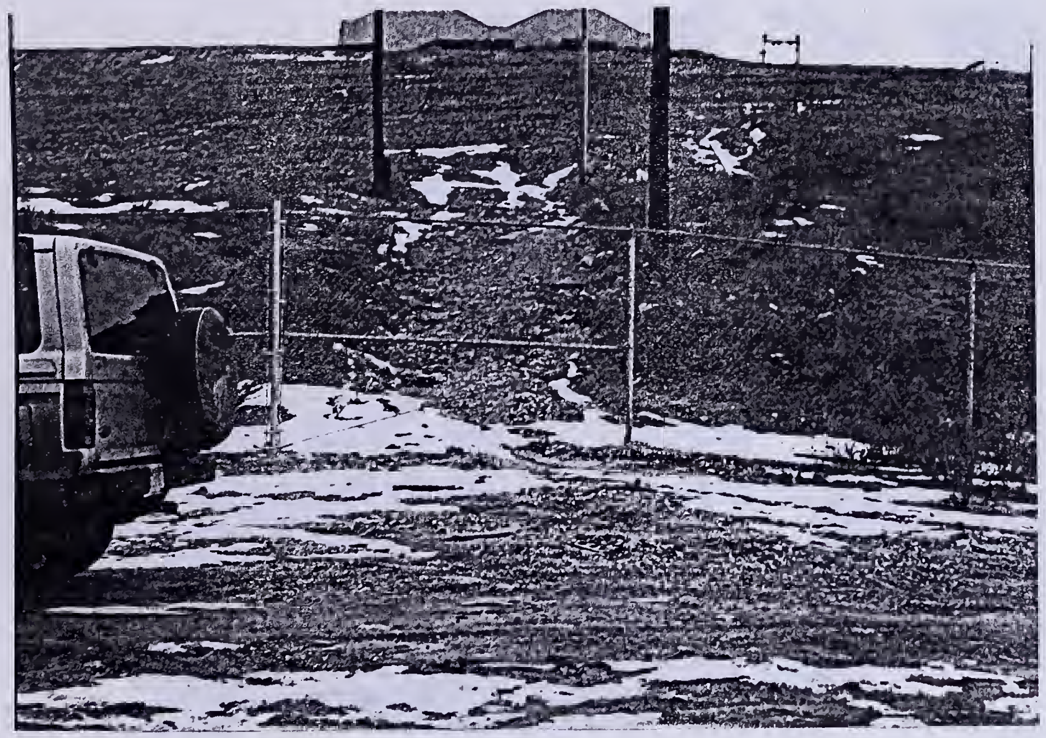
MAP INDEX: M-27-81

MINE: Bellona

SUBJECT: Wash to Broadway St.

AERIAL PHOTO INDEX: P6-81

PAGE 2 OF 2



SAFETY HAZARD: See page 1

HEALTH HAZARD: See page 1

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 1

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Mt. Con - Steward

VIEW: Looking Northwesterly

PHOTO NEGATIVE INDEX: G14-5

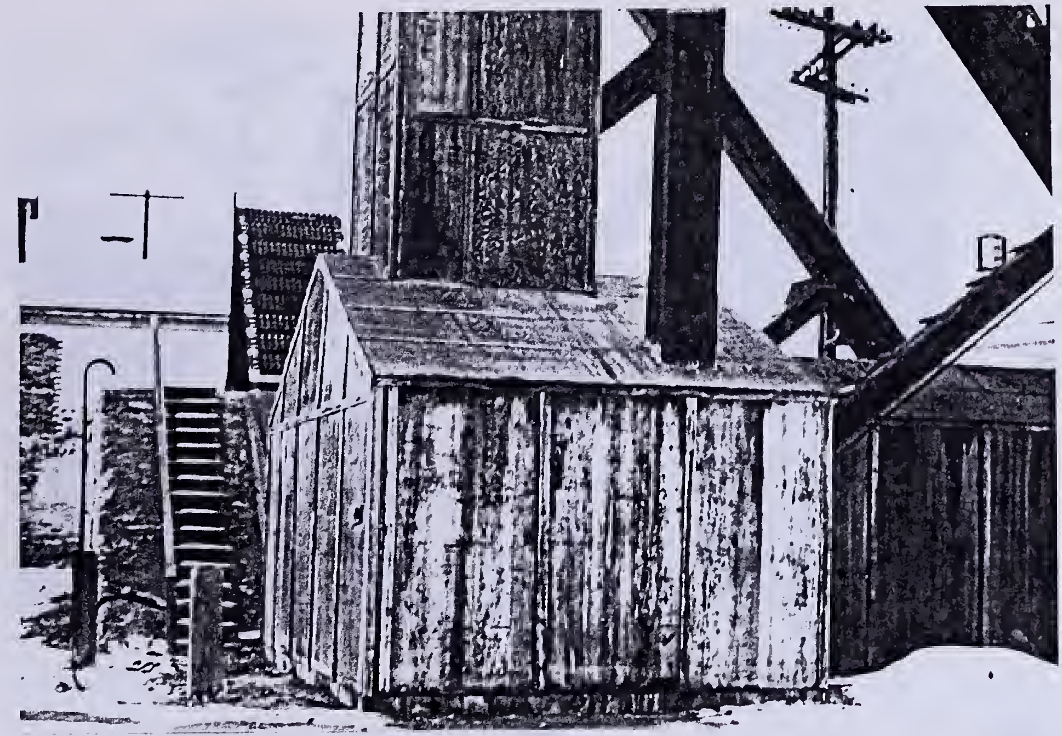
MAP INDEX: M-27-89

MINE: Parrott

SUBJECT: Shaft House

AERIAL PHOTO INDEX: P6-89

PAGE 1 OF 3



SAFETY HAZARD: The Parrott shaft and wooden headframe is housed in a wooden frame structure vulnerable to fire. The shaft collar within the building is not covered by a bulkhead. Although the shaft is within the major Anaconda fence it is a serious hazard to those persons who enter the yard by climbing or crawling under the fence. The shaft is wet but not under water and will eventually cave.

HEALTH HAZARD: As the water rises in the underground, "bad air" will be forced up the shaft.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 4

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Mt. Con - Steward

VIEW: Lookinf Southeasterly

PHOTO NEGATIVE INDEX: G14-6

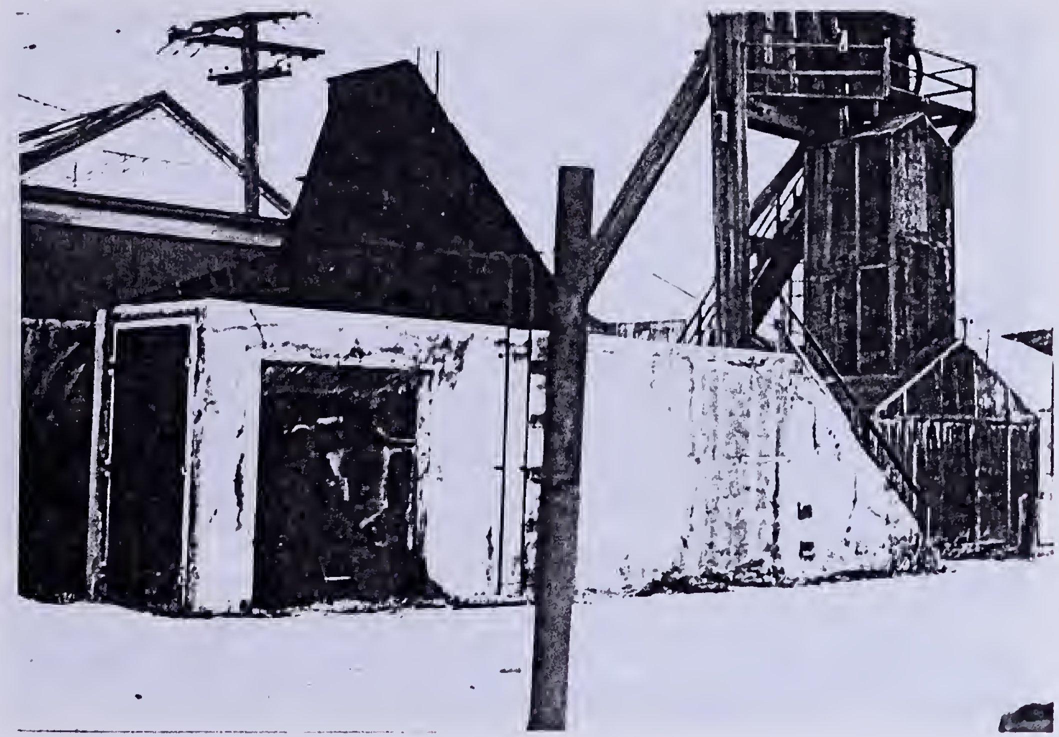
MAP INDEX: M-27-90

MINE: Parrott

SUBJECT: Fan House

AERIAL PHOTO INDEX: P6-90

PAGE 2 OF 3



SAFETY HAZARD: Fan housing of concrete is attached to the shaft house of wood. Hazard the same as page 1.

HEALTH HAZARD: Same as page 1

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 4

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Mt. Con - Steward

VIEW: Looking Northeasterly

PHOTO NEGATIVE INDEX: G16-#21

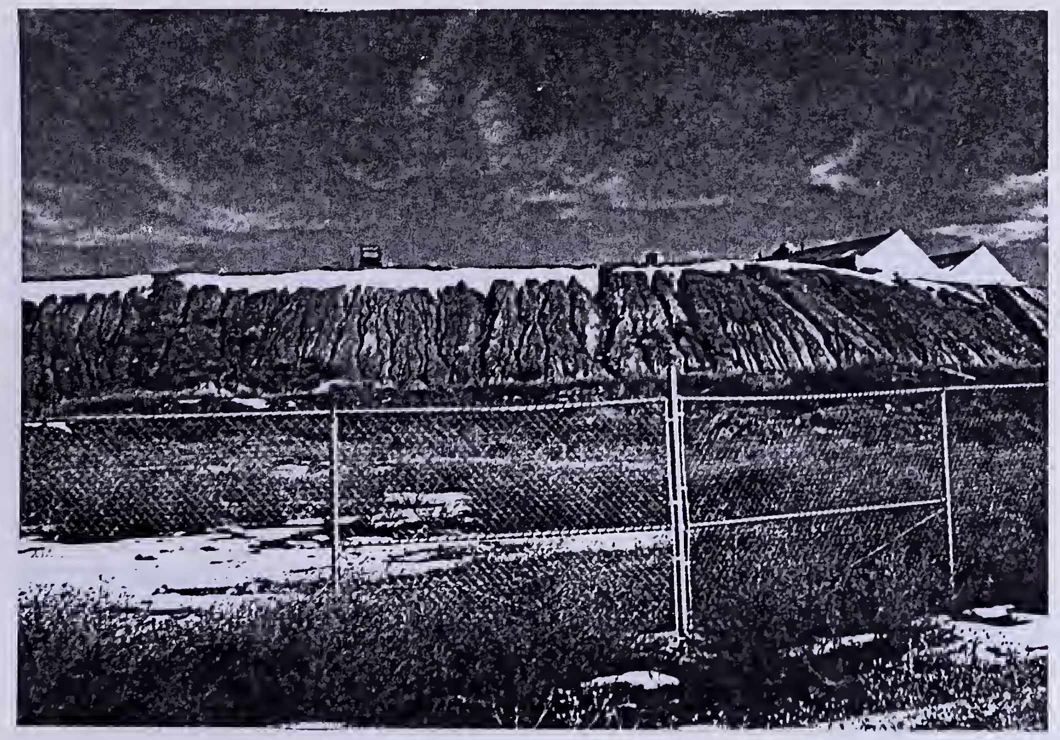
MAP INDEX: M-27-91

MINE: Parrott

SUBJECT: Waste Dump

AERIAL PHOTO INDEX: P6-91

PAGE 3 OF 3



SAFETY HAZARD: N/A

HEALTH HAZARD: Heavy erosion of the Parrott waste dump flows down onto Arizona and Park Streets creating a dust condition on the streets which is hazardous to persons breathing the somewhat acid material.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR:

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Mt. Con - Steward

VIEW: Looking Northwesterly

PHOTO NEGATIVE INDEX: G16-11

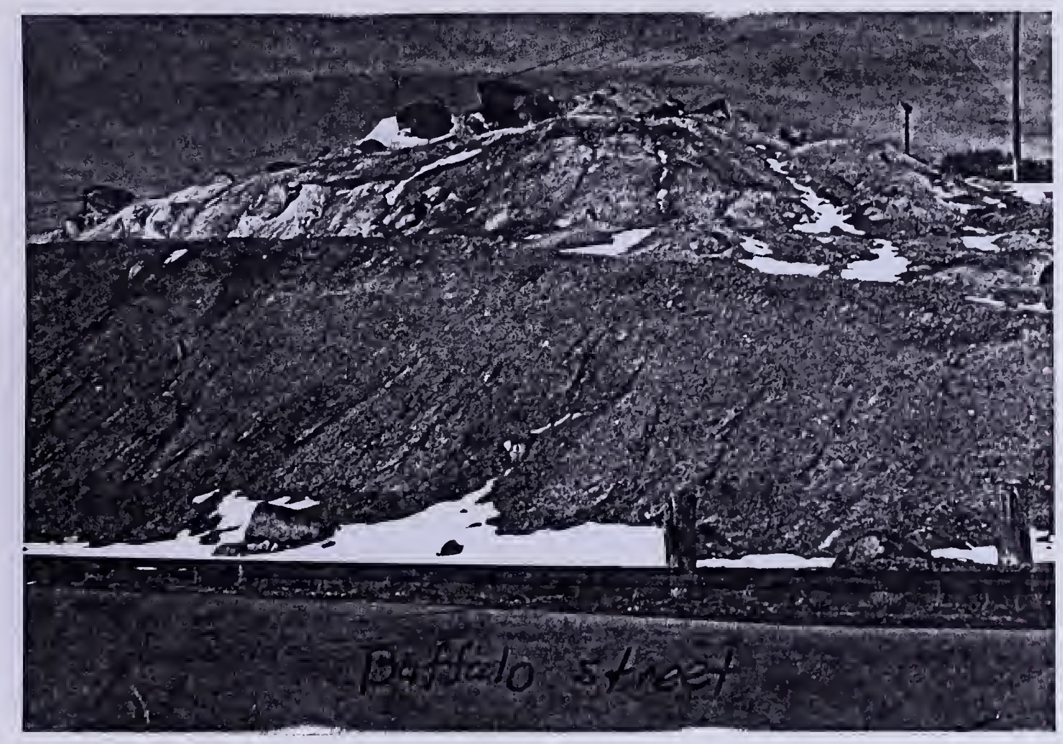
MAP INDEX: M-23-105

MINE: Carrie

SUBJECT: Waste Dump & Shaft position

AERIAL PHOTO INDEX: P6-105

PAGE 1 OF 1



SAFETY HAZARD: The Carrie shaft was filled many years ago. There is no evidence of subsidence in the shaft area.

HEALTH HAZARD: The Carrie dump is eroding considerably causing a dusting condition.

HEALTH HAZARD FACTOR: 1

SAFETY HAZARD FACTOR: 0

MISCELLANEOUS COMMENTS:

AREA: Mt. Con - Steward

VIEW: Looking Northwesterly

PHOTO NEGATIVE INDEX: G15-22

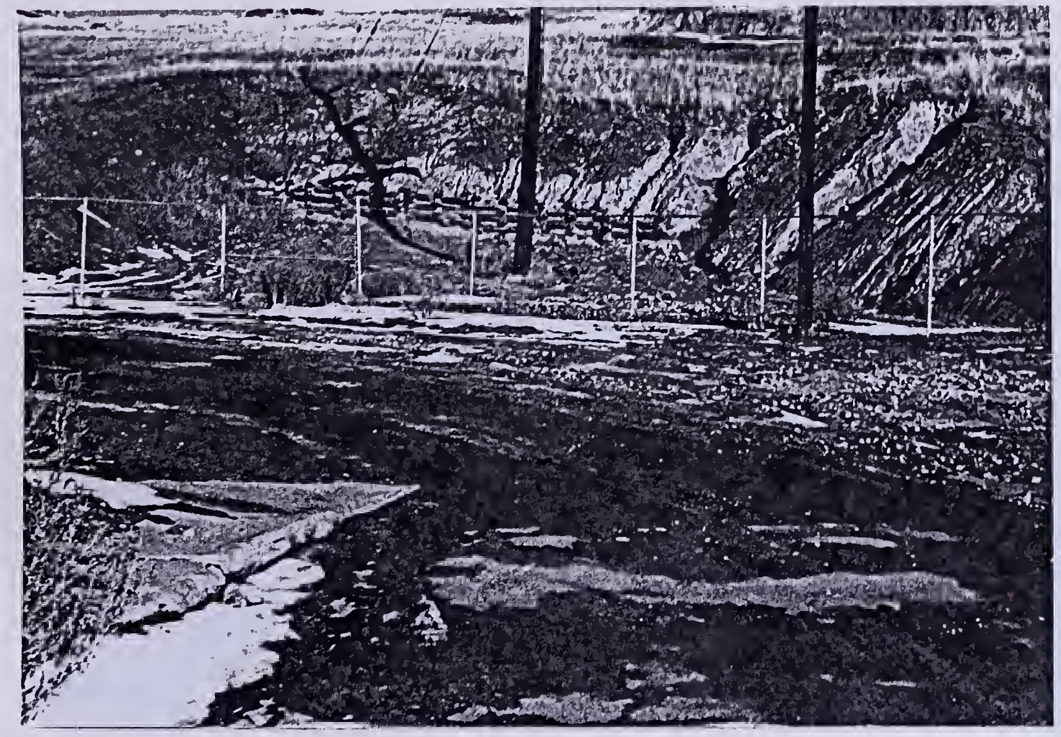
MAP INDEX: I-27-104

MINE: Moonlight

SUBJECT: Yard area

AERIAL PHOTO INDEX: P6-104

PAGE 1 OF 1



SAFETY HAZARD: The photo taken from the corner of Covert and Granite Streets, shows the remanents of the Moonlight yard area. The shaft was incorporated into the pit and is within the Mining Permit area.

HEALTH HAZARD: The Moonlight yard area was filled with waste rock and reshaped. Serious erosion has taken place and the runoff has deposited the debris on Granite Street causing a dusting condition of acid waste.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 0

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Mt. Con - Steward
VIEW: Looking Southwesterly
PHOTO NEGATIVE INDEX: G16-13
MAP INDEX: M-27-103

MINE: Humbolt
SUBJECT: Shaft Collar position
AERIAL PHOTO INDEX: P6-103

PAGE 1 OF 1

SAFETY HAZARD: The Humbolt shaft was 500 feet deep and connected to the Buffalo workings. The shaft was filled and the area around the shaft was shaped. There is no hazard.

HEALTH HAZARD: The acid dumpmaterial was spread out over a larger area. The acid waste rock will not support vegetation and therefore is susceptible to dusting. The area is adjacent to residences.

HEALTH HAZARD FACTOR: 2
SAFETY HAZARD FACTOR: 0
MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Mt. Con - Steward

VIEW: Looking Easterly

PHOTO NEGATIVE INDEX: G13-3

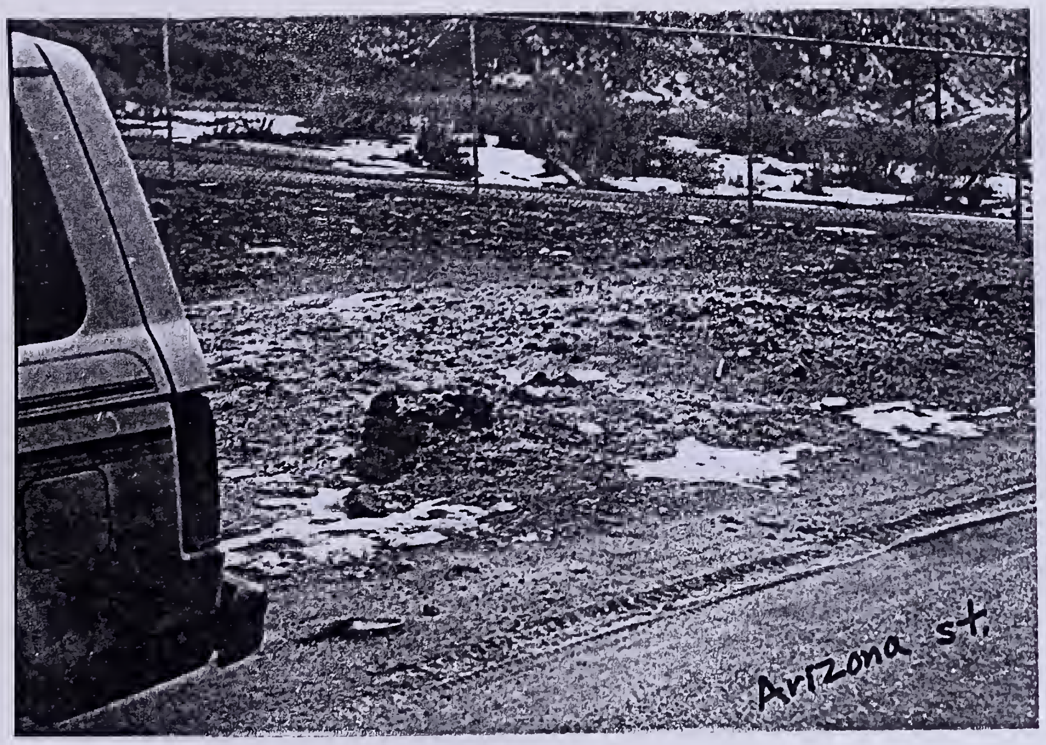
MAP INDEX: M-27-102

MINE: Washoe

SUBJECT: Shaft Location

AERIAL PHOTO INDEX: P6-102

PAGE 1 OF 1



SAFETY HAZARD: The 500 foot deep shaft is located on the east side of Arizona Street between Quartz and Copper Streets. The shaft has subsided several times and the subsidence area was filled each time. The shaft was never bulkheaded and subsidence could take place again. The surface is unlikely to open up into the shaft section, therefore not considered to be severely hazardous.

The gray area in the photo is the shaft position.

HEALTH HAZARD: N/A

HEALTH HAZARD FACTOR:

SAFETY HAZARD FACTOR: 2

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Mt. Con - Steward

VIEW: Looking East

PHOTO NEGATIVE INDEX: G15- 14

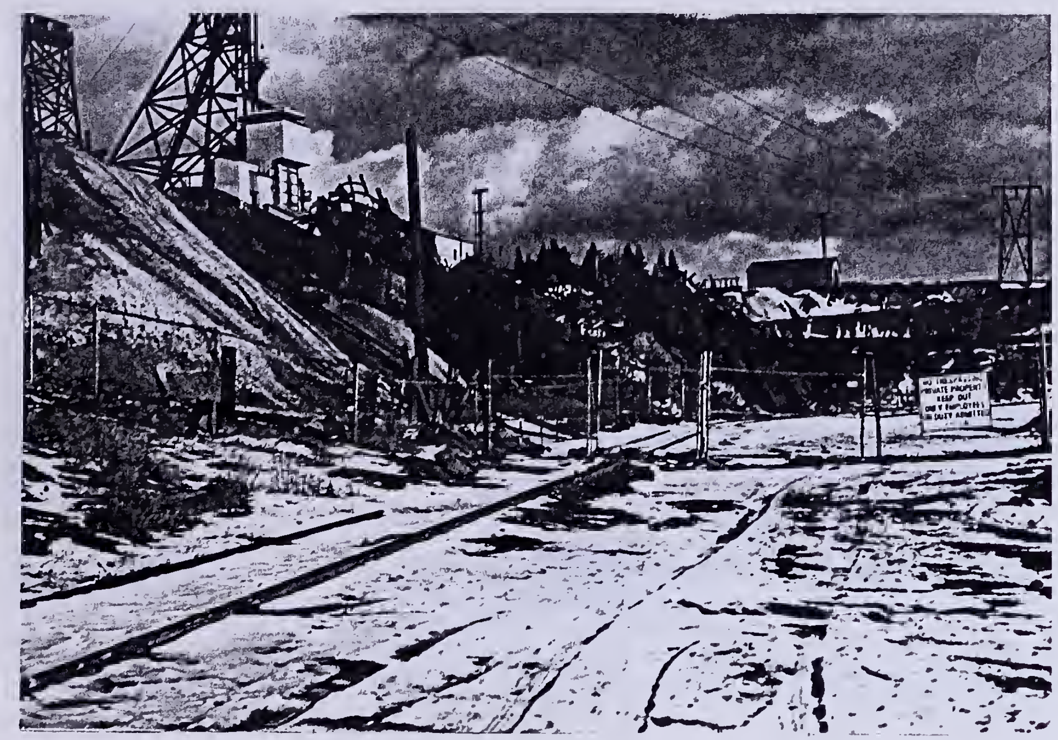
MAP INDEX: M-27-97

MINE: Mt. Con

SUBJECT: Old ore bins

AERIAL PHOTO INDEX: P6-97

PAGE 2 OF 2



SAFETY HAZARD: The ore bins at the Mt. Con were knocked down preparatory to cutting them up for scrap. The job was never completed leaving a dangerous situation for children playing. Although the area is fenced there is evidence that children have entered the yard.

HEALTH HAZARD: N/A

HEALTH HAZARD FACTOR: 0

SAFETY HAZARD FACTOR: 4

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Mt. Con - Steward

VIEW:

PHOTO NEGATIVE INDEX: G14-4

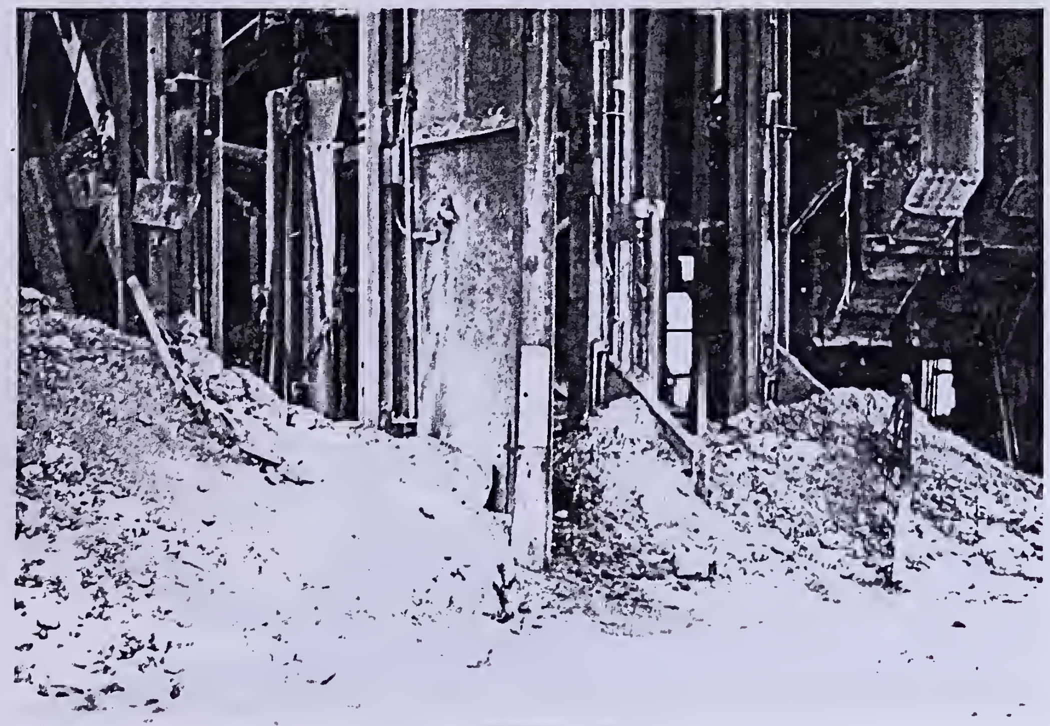
MAP INDEX: M-27-96

MINE: Mt. Con

SUBJECT: Shaft

AERIAL PHOTO INDEX: P6-96

PAGE 1 OF 2



SAFETY HAZARD: The shaft has been bulkheaded with wood about 15 feet below the collar. The shaft is filled with waste material from the bulkhead to the surface. Although a breather was placed through the bulkhead, it will eventually rot and fail opening the shaft to the surface. The area is fenced but is still vulnerable to entrance. The Mt. Con shaft is 5200 feet deep.

HEALTH HAZARD: "Bad air" forced up the shaft by the rising water becomes a hazard to persons standing or walking nearby.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 5

MISCELLANEOUS COMMENTS:

AREA: Mt. Con - Steward

VIEW: Looking Northeasterly

PHOTO NEGATIVE INDEX: G16-9

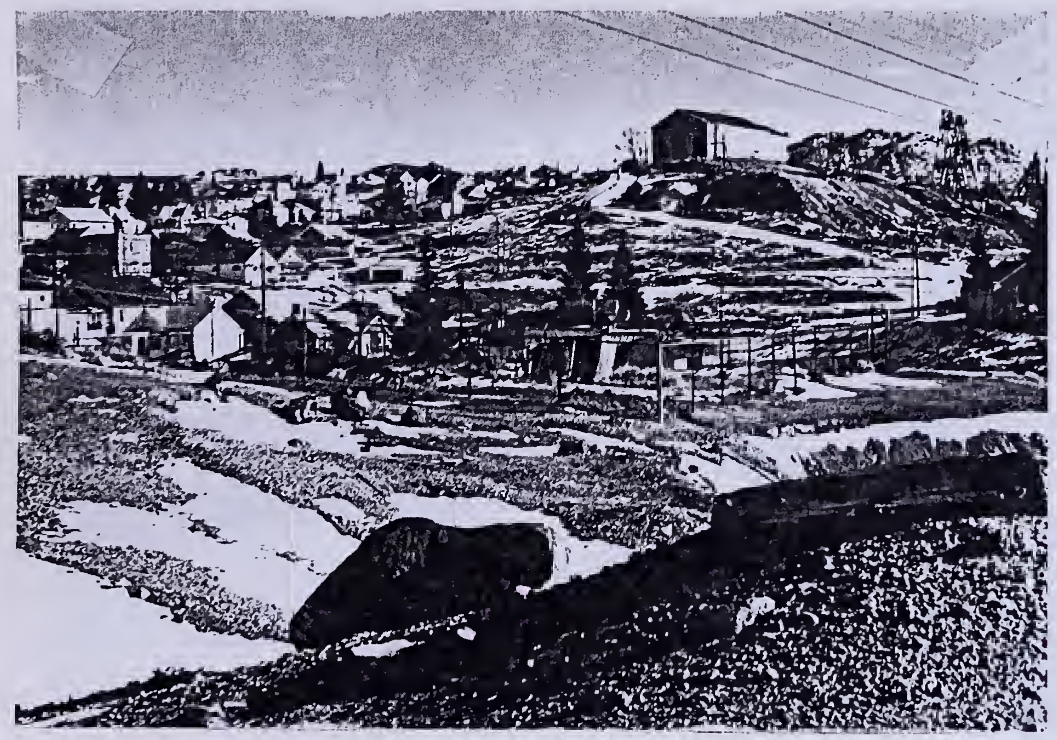
MAP INDEX: M-27-86

MINE: Buffalo

SUBJECT: Shaft Collar

AERIAL PHOTO INDEX: P6-86

PAGE 1 OF 3



SAFETY HAZARD: The Buffalo shaft was bulkheaded at or very near the surface after a fire burned the shaft house and a portion of the headframe. The bulkhead is covered with waste material. The shaft is 2200 feet deep and the bulkhead will eventually rot and fail causing a very serious hazard. The shaft is located in a heavily populated area. The mine yard, although fenced is completely vulnerable to the public, especially children.

HEALTH HAZARD: The mine will eventually fill with water and during the process "bad air" will be forced up the shaft.

HEALTH HAZARD FACTOR: 3

SAFETY HAZARD FACTOR: 5

MISCELLANEOUS COMMENTS:

AREA: Mt. Con - Steward

VIEW: Looking Northerly

PHOTO NEGATIVE INDEX: G15-17

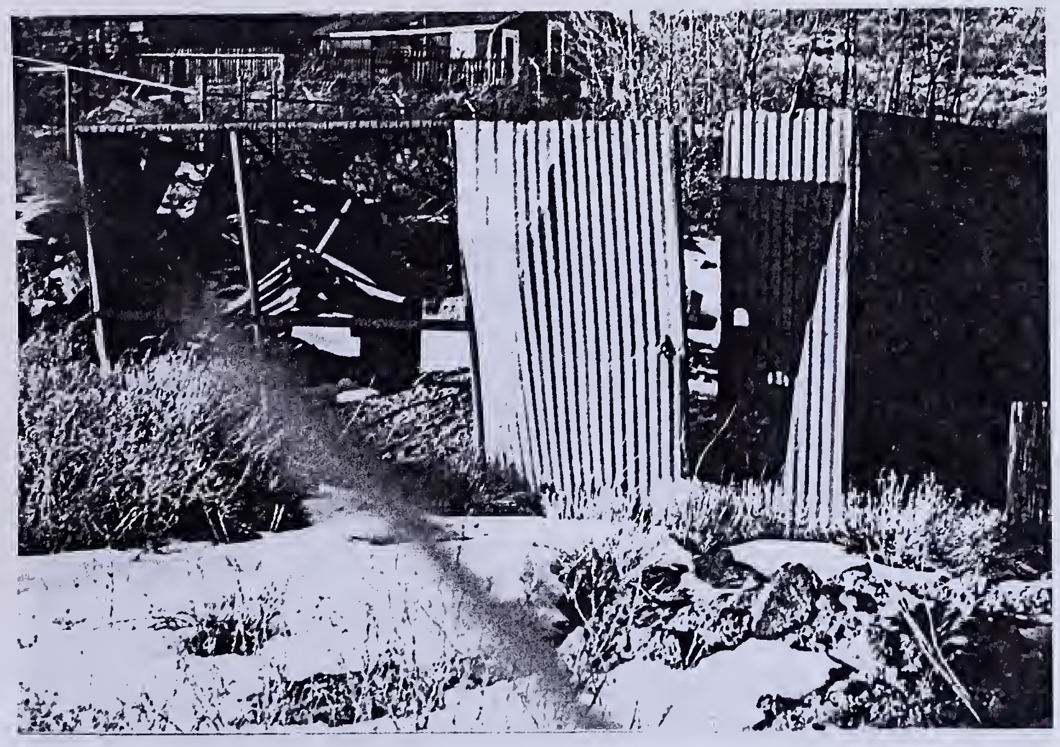
MAP INDEX: M-27-87

MINE: Buffalo

SUBJECT: Close-up of Shaft Position

AERIAL PHOTO INDEX: P6-87

PAGE 2 OF 3



SAFETY HAZARD: The yard has not been cleaned up well after the shaft closure. The debris is a hazard to children even if they do not enter the yard.

The overall hazard is noted on page 1

HEALTH HAZARD: See page 1

HEALTH HAZARD FACTOR: 3

SAFETY HAZARD FACTOR: 5

MISCELLANEOUS COMMENTS:

AREA: Mt. Con - Steward

VIEW: Looking Northwesterly

PHOTO NEGATIVE INDEX: G13-13

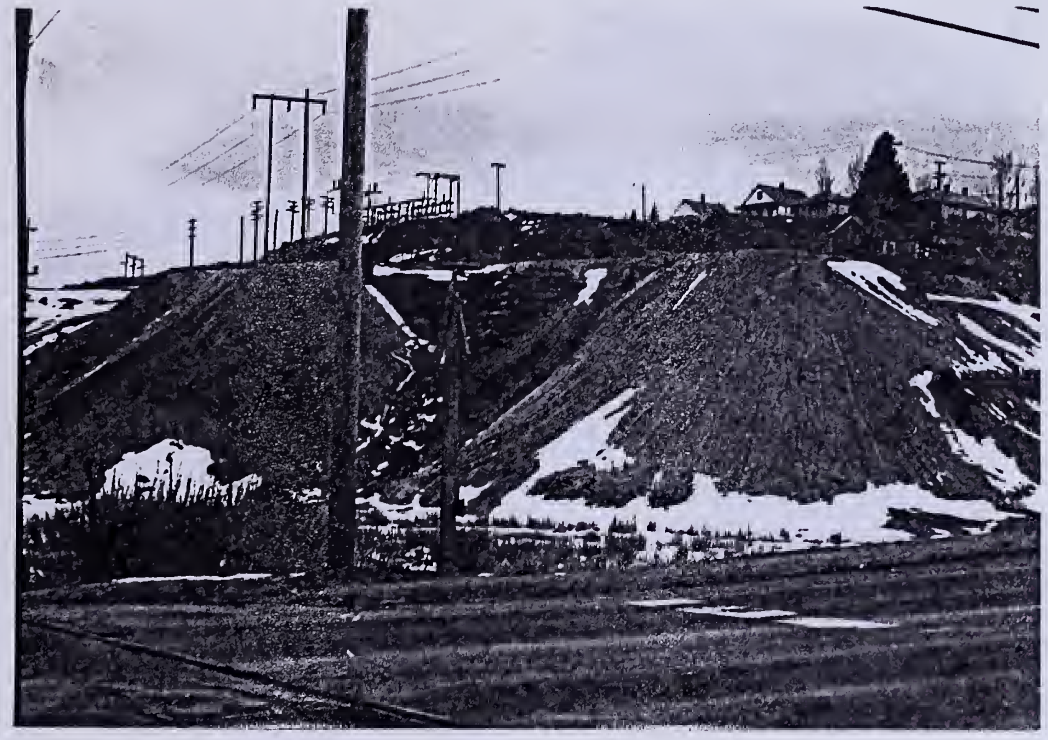
MAP INDEX: M-27-88

MINE: Buffalo

SUBJECT: Waste Dump

AERIAL PHOTO INDEX: P6-88

PAGE 3 OF 3



HEALTH HAZARD: The dump is eroding heavily to Buffalo and Main Streets. The dump is located within a residential area and dust from the surface of the dump is hazardous to the occupants.

SAFETY HAZARD: The crib work on the dump constitutes a small hazard to children climbing on it.

HEALTH HAZARD FACTOR: 1

SAFETY HAZARD FACTOR: 2.5

MISCELLANEOUS COMMENTS:

AREA: Mt. Con - Steward

VIEW: Looking Southwesterly

PHOTO NEGATIVE INDEX: G15-24

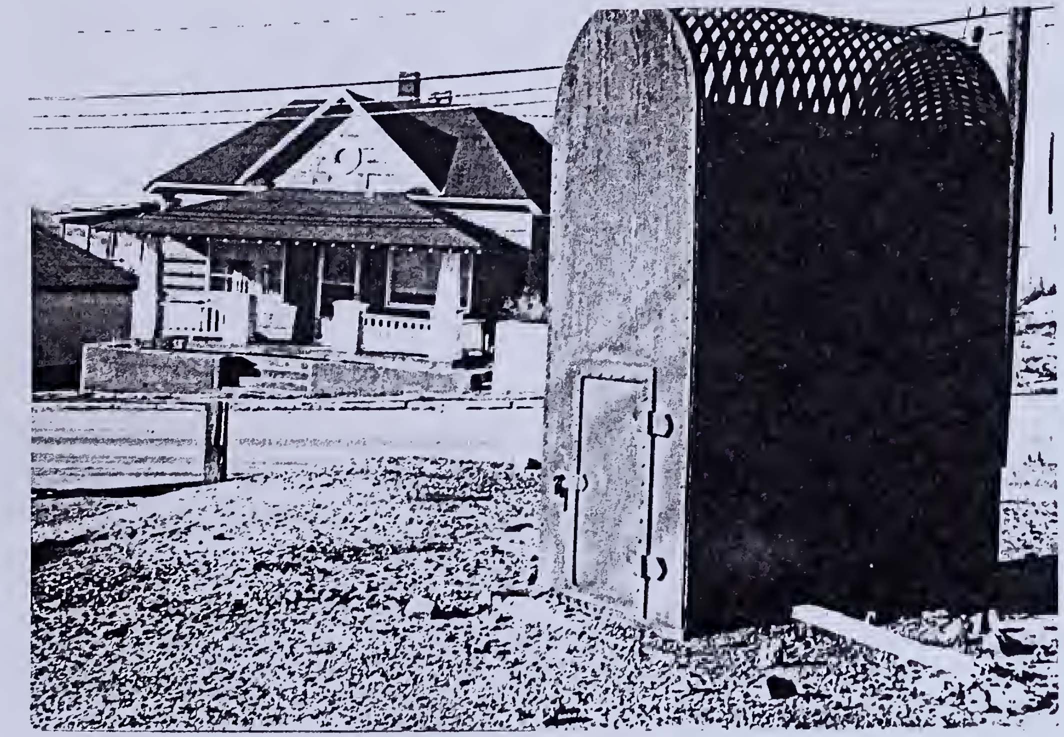
MAP INDEX: M-27-99

MINE: Clear Grit

SUBJECT: Shaft & Shaft Collar

AERIAL PHOTO INDEX: ~~P6-99~~

PAGE 1 OF 1



SAFETY HAZARD: The Clear Grit shaft is 600 feet deep and protected on the collar with a steel housing with padlocked door. The shaft is in a heavy populated area with many children who play around the shaft. The shaft collar is vulnerable to caving and the padlocked door to vandalism and entrance into the shaft proper. The condition is very hazardous.

HEALTH HAZARD: N/A

HEALTH HAZARD FACTOR:

SAFETY HAZARD FACTOR: 5

MISCELLANEOUS COMMENTS:

WALKERVILLE AREA

The Walkerville Area is the largest study area and encompasses some of the most severe hazards present in the Butte district. The Alice pit and waste dump is by far the most hazardous site in the area. The sheer walls of the pit proper are subject to immediate subsidence and the dump is a source of wind erosion and dusting causing a health hazard, as well as, a safety hazard, The area was fenced at one time, but approximately 25% of the fence has now been removed, opening the area to the public. The dump, as well as, the pit perimeter is being used by bicycles, motorcycles, and automobiles.

The Gray Rock is the next most hazardous site with an 1800 foot shaft sealed on the surface with only an unburied wooden bulkhead. The area is open to the public, in close proximity to Walkerville, and shows evidence of children at play.

The Moose shaft has been bulkheaded on the surface in recent years using timber planking. The shaft is over 3000 feet deep, subject to eventual caving, and open to the public. This makes the site very hazardous and should be considered the third most important hazard in the Walkerville area.

Following the Moose, there are several small sites that are very hazardous, particularly to children playing in the area. These are the Valdemere, Belle of Butte, Eveline,

Venus, Magna Charta, Paymaster, and the Rising Star. Each of these sites require corrective action of some type or further investigation.

In conclusion, the Walkerville area presents some very severe health and safety hazards for the local residents. All areas studied are presently owned by the Anaconda Co. and are reviewed in detail in the following body of this report.

AREA: Walkerville

VIEW: Looking Northeasterly

PHOTO NEGATIVE INDEX: G3 - 8

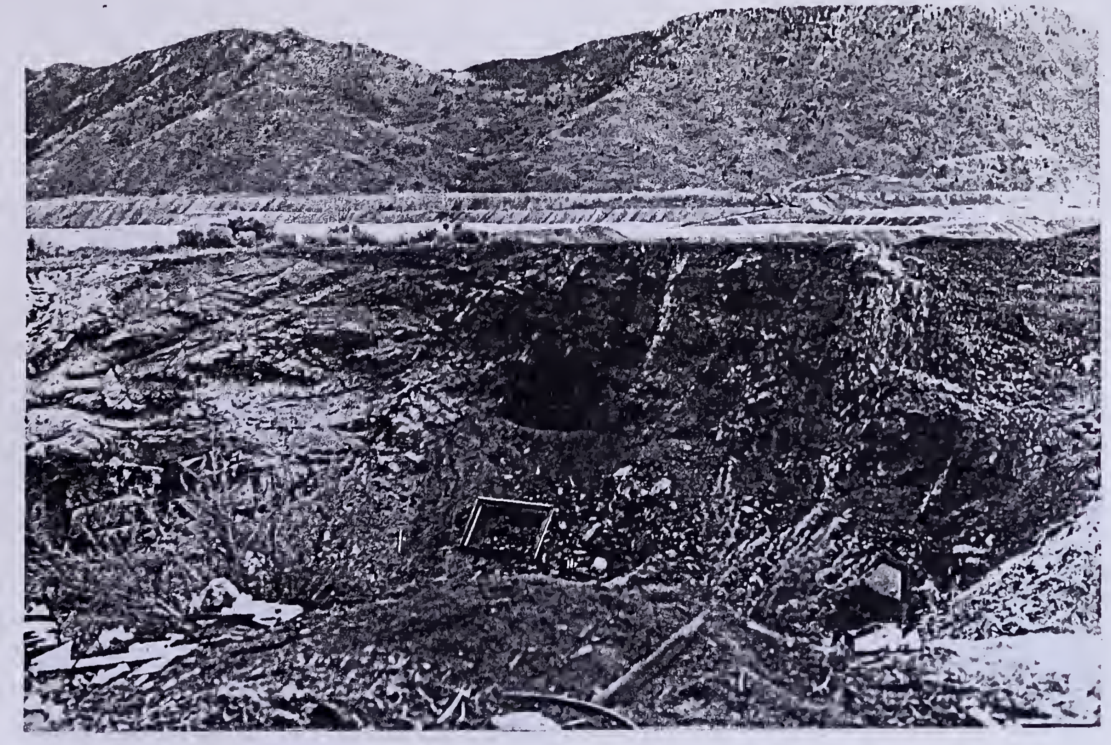
MAP INDEX: U-27-44

MINE: Valdemere

SUBJECT: Old adit

AERIAL PHOTO INDEX: P5 - 44

PAGE 1 OF 1



HEALTH HAZARD: Barren spoil and open cut subject to dusting. Scrap piles of metal and glass in the area which is subject to children playing.

SAFETY HAZARD: The cut exposed an underground opening which has not been protected. The area is frequented by children and is a source of danger from caving. The roof of the tunnel is not supported and can cave at any moment.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 3

MISCELLANEOUS COMMENTS:

AREA: Walkerville

VIEW: Looking Northeasterly

PHOTO NEGATIVE INDEX: G3 - 2

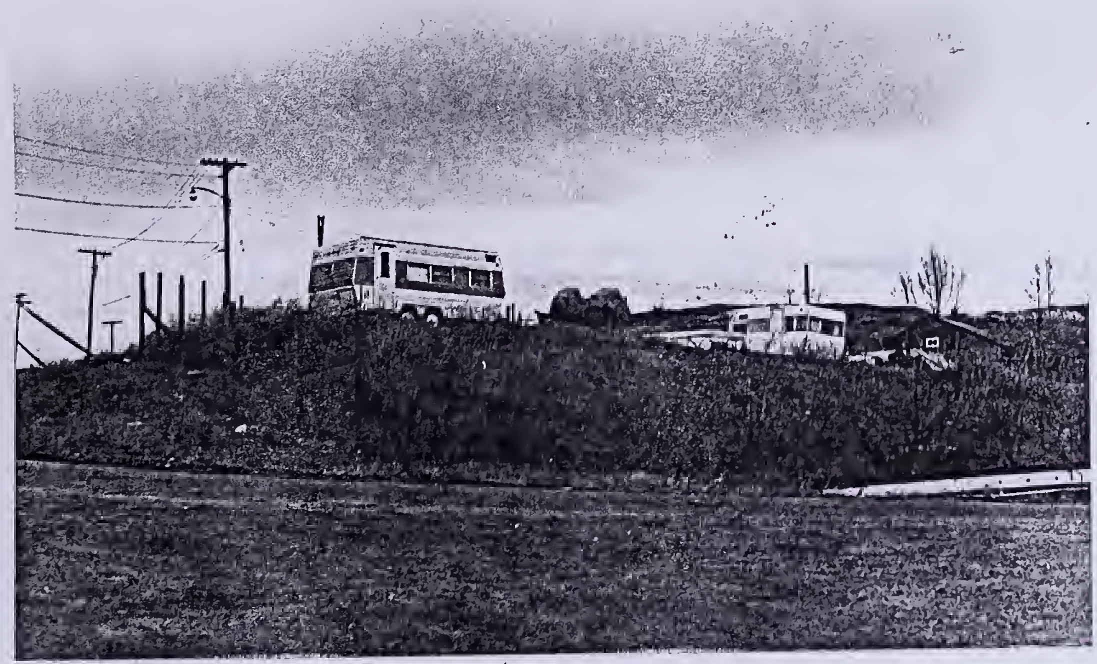
MAP INDEX: Q-27-45

MINE: Belle of Butte

SUBJECT: Shaft Location

AERIAL PHOTO INDEX: P5 - 45

PAGE 1 OF 1



SAFETY HAZARD: Belle of Butte in the area of the trailers. Bulkheaded on surface and covered with waste material. The bulkhead could cave at anytime and leave a hole up to 500 feet deep.

HEALTH HAZARD: N/A

HEALTH HAZARD FACTOR: 1

SAFETY HAZARD FACTOR: 4

MISCELLANEOUS COMMENTS:

AREA: Walkerville

VIEW: Looking Northwesterly

PHOTO NEGATIVE INDEX: G2 - 19A

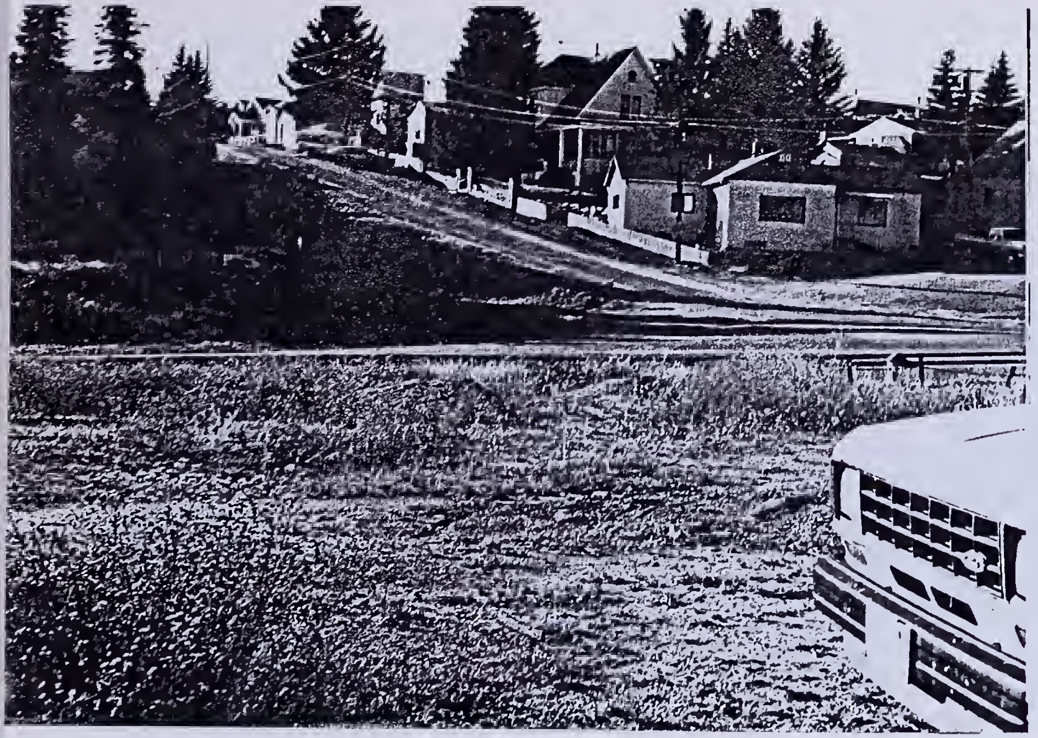
MAP INDEX: Q-23-23

MINE: Venus

SUBJECT: Shaft Collar Area

AERIAL PHOTO INDEX: P5 - 23

PAGE 1 OF 1



SAFETY HAZARD: The Venus shaft is located near the center of this vacant lot at the intersection of Daly Street and Walkerville Drive. The shaft is several hundred feet deep and is probably only covered with a wooden bulkhead just under the surface of the lot. This bulkhead will fail at some future time causing an extremely dangerous condition. The area is open to the public and used for play by children.

HEALTH HAZARD: Undetermined

HEALTH HAZARD FACTOR: 1

SAFETY HAZARD FACTOR: 3

MISCELLANEOUS COMMENTS:

AREA: Walkerville

VIEW: Looking South

PHOTO NEGATIVE INDEX: G2 - 20A

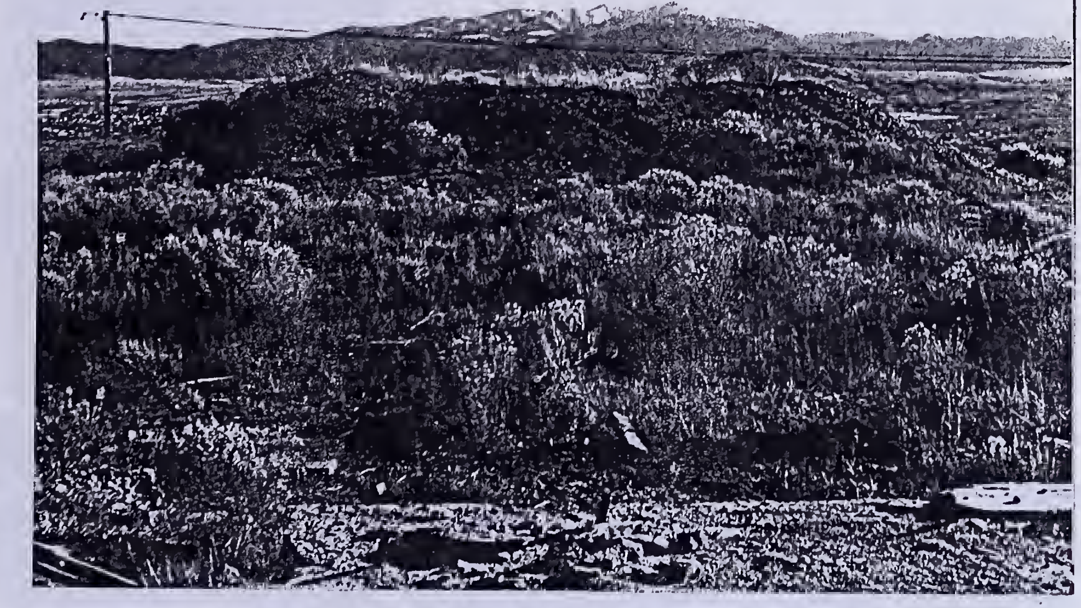
MAP INDEX: Q-23-22

MINE: Eveline

SUBJECT: Shaft Collar

AERIAL PHOTO INDEX: P6 - 22

PAGE 1 OF 2



SAFETY HAZARD: The Eveline shaft was bulkheaded on the surface and then buried. The shaft is 700' deep. The bulkhead will likely fail causing severe subsidence and an extremely dangerous condition. The area is open to the public.

HEALTH HAZARD: Semi-barren spoil pile , concrete hoist foundation with protruding anchor bolts.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 3

MISCELLANEOUS COMMENTS:

AREA: Walkerville

VIEW: Looking Northwesterly From corner of Walkerville Drive and 16th Street.

PHOTO NEGATIVE INDEX: G6 - 7

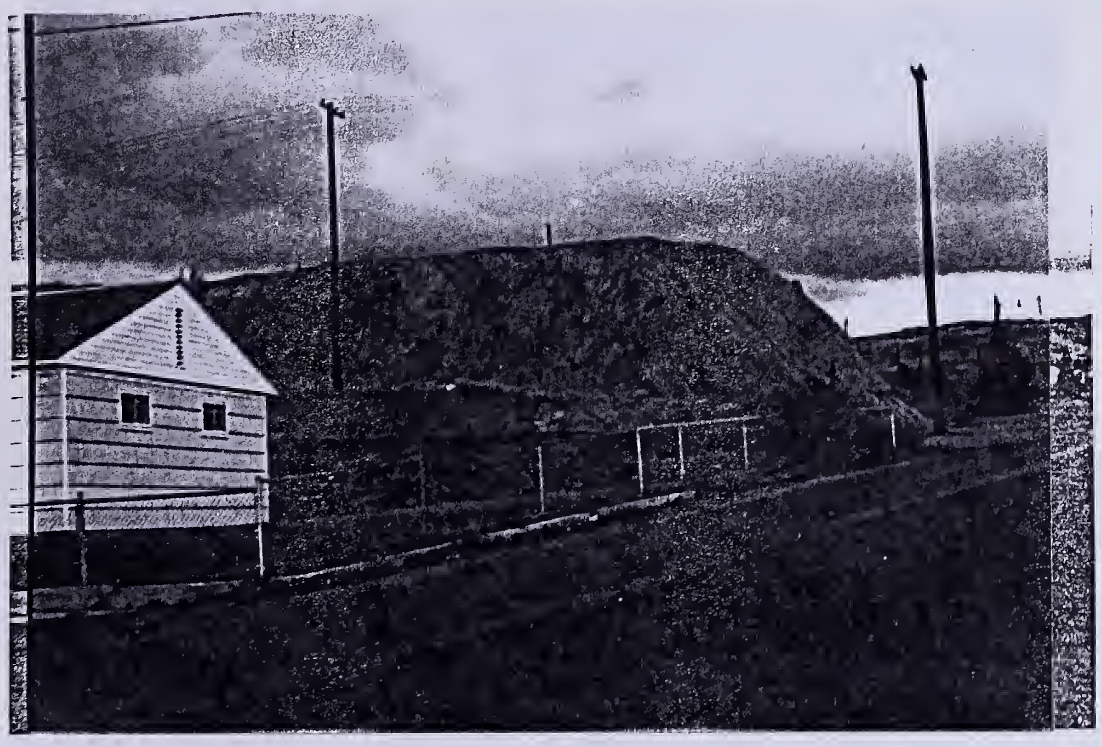
MAP INDEX: Q-23-46

MINE: Eveline

SUBJECT: Waste Dump - South Side

AERIAL PHOTO INDEX: P6 - 46

PAGE 2 OF 2



HEALTH HAZARD: Close proximity to heavily populated area. Dusting with slightly acid material from northerly winds which are predominate in Butte.

SAFETY HAZARD: N/A

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 1

MISCELLANEOUS COMMENTS:

AREA: Walkerville

VIEW: Looking Northerly

PHOTO NEGATIVE INDEX: G5 - 9

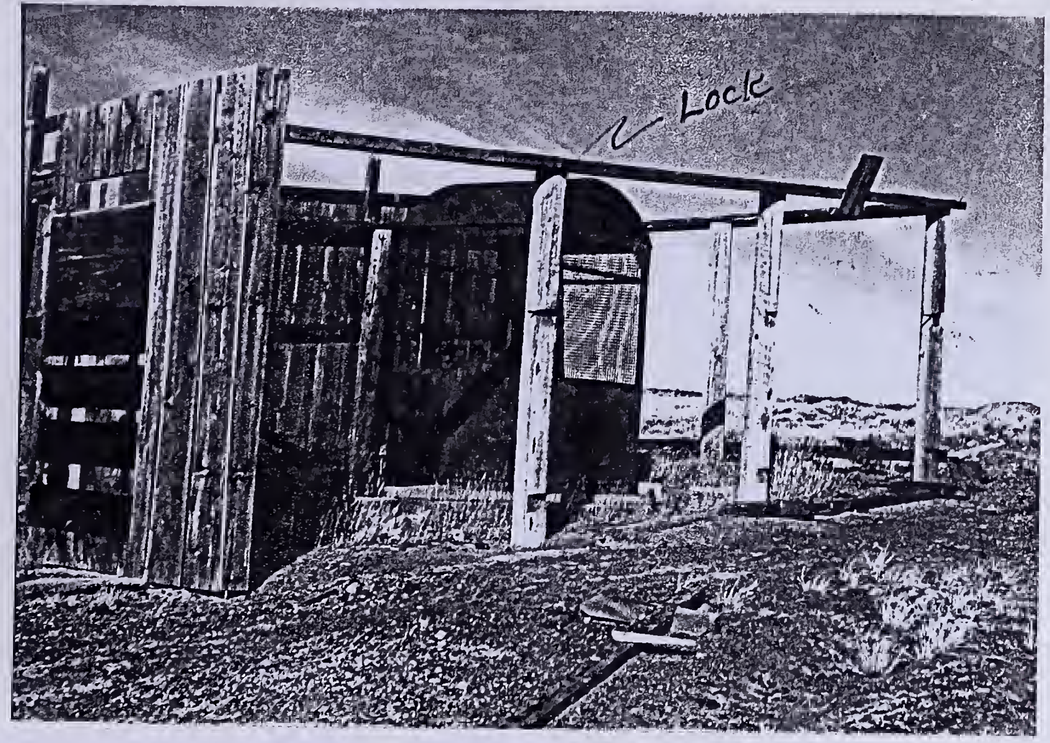
MAP INDEX: U-27-35

MINE: 351 Raise - Magna Charta

SUBJECT: Surface with inadequate protection

AERIAL PHOTO INDEX: P5 - 35

PAGE 1 OF 4



SAFETY HAZARD: Open shaft 300 ft. deep protected only by the iron cage. The shaft has ladders in place and is connected to the underground workings. The area is open to the public and only protected by a standard lock shown in the photo. This is a potentially dangerous condition for children.

HEALTH HAZARD: Undetermined

HEALTH HAZARD FACTOR: 1

SAFETY HAZARD FACTOR: 4

MISCELLANEOUS COMMENTS:

REA: Walkerville

VIEW: Looking Northeasterly

PHOTO NEGATIVE INDEX: G5 - 7

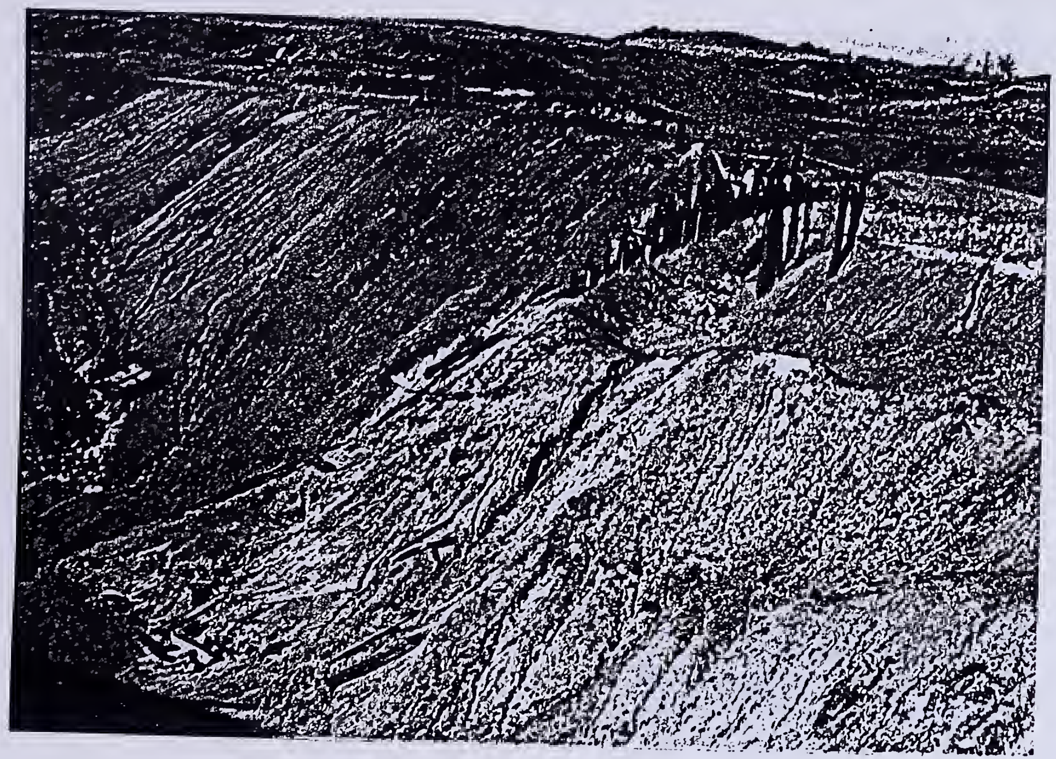
MAP INDEX: U-27-36

INE: Magna Charta

SUBJECT: Magna Charta Waste Dump

AERIAL PHOTO INDEX: P5 -36

PAGE 2 OF 4



ALTH HAZARD: Large barren spoil piles with embedded wood and metal scrap. Acid composition has prevented re-vegetation. Subject to wind and rain erosion.

SAFETY HAZARD: Steep-walled waste dump with protruding scrap. Open to the public.

ALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 1.5

ISCELLANEOUS COMMENTS:

AREA: Walkerville

VIEW: Looking Southeasterly

PHOTO NEGATIVE INDEX: G5 - 8

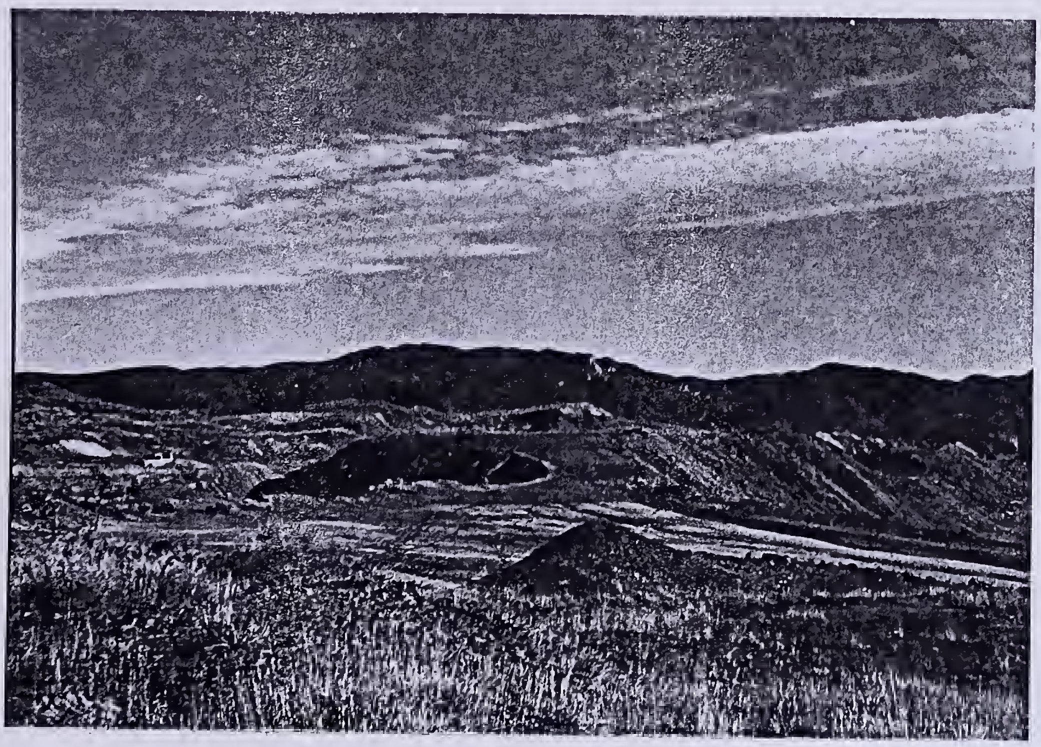
MAP INDEX: U-27-37

MINE: Magna Charta

SUBJECT:

AERIAL PHOTO INDEX: P - 37

PAGE 3 OF 4



SAFETY HAZARD: Same as Page 2

HEALTH HAZARD: Same as Page 2

HEALTH HAZARD FACTOR:

SAFETY HAZARD FACTOR:

MISCELLANEOUS COMMENTS:

AREA: Walkerville

VIEW: Looking Northwesterly

PHOTO NEGATIVE INDEX: G5 - 6

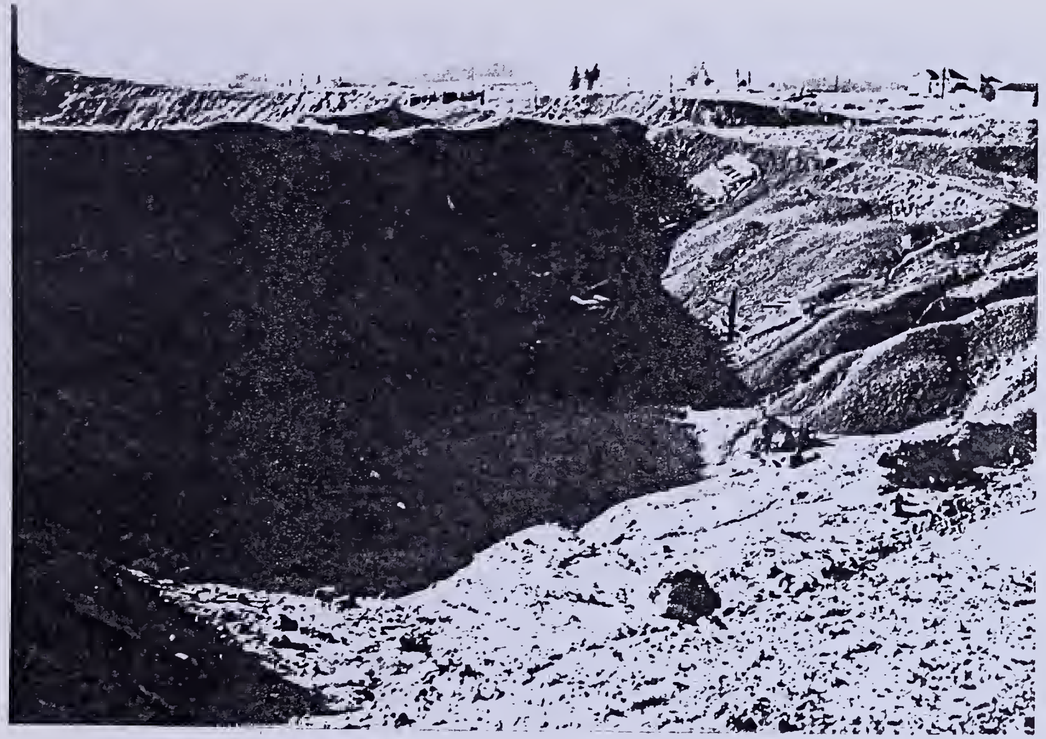
MAP INDEX: U-27-38

MINE: Magna Charta

SUBJECT:

AERIAL PHOTO INDEX: P - 38

PAGE 4 OF 4



SAFETY HAZARD: Large subsidence from unknown causes. Steep-walled pit open to the public.

HEALTH HAZARD: Barren spoil piles with unattended garbage dump and scrap piles. Subject to wind and rain erosion. Acid composition prevents vegetation.

HEALTH HAZARD FACTOR: 2

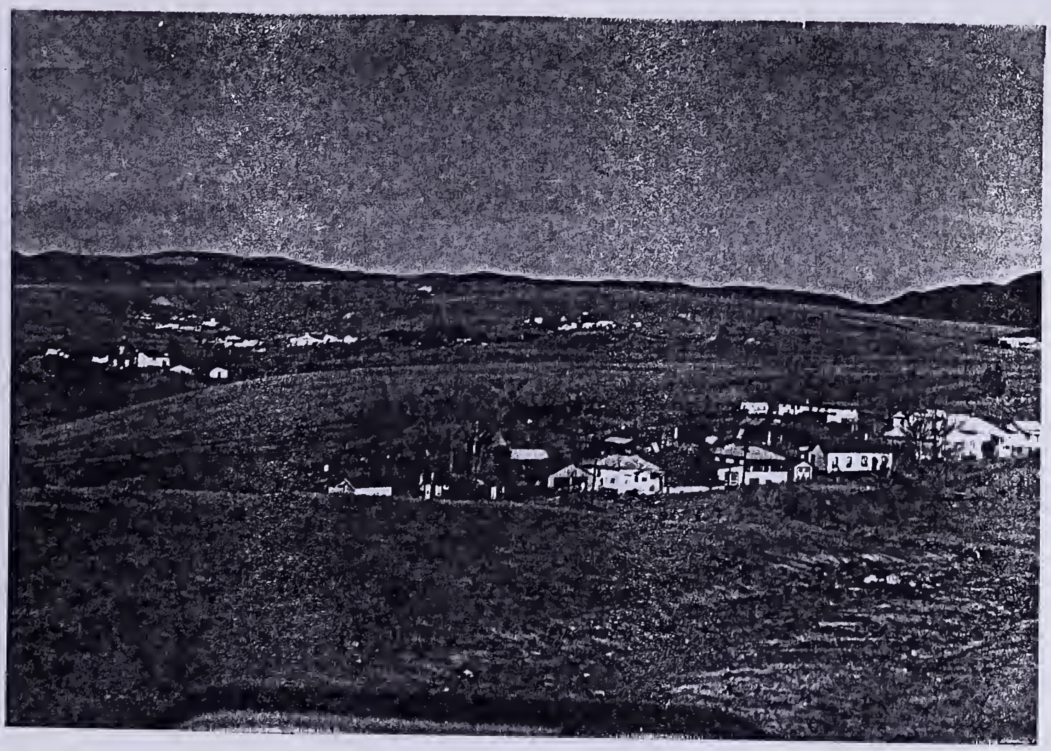
SAFETY HAZARD FACTOR: 1.5

MISCELLANEOUS COMMENTS:

AREA: Walkerville
VIEW: Looking Northeast
PHOTO NEGATIVE INDEX: G2 - 2A
MAP INDEX: U-23-39

MINE: Minnie Irvine
SUBJECT: Waste Dump
AERIAL PHOTO INDEX: P5 - 39

PAGE 1 OF 1



SAFETY HAZARD: N/A

HEALTH HAZARD: Waste dump material from the Alice pit, stacked and leveled off for a playground. Slightly acid material not amenable to growth of vegetation and vulnerable to dusting from winds.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 1

MISCELLANEOUS COMMENTS:

AREA: Walkerville

VIEW: Looking Westerly

PHOTO NEGATIVE INDEX: G3 - 15

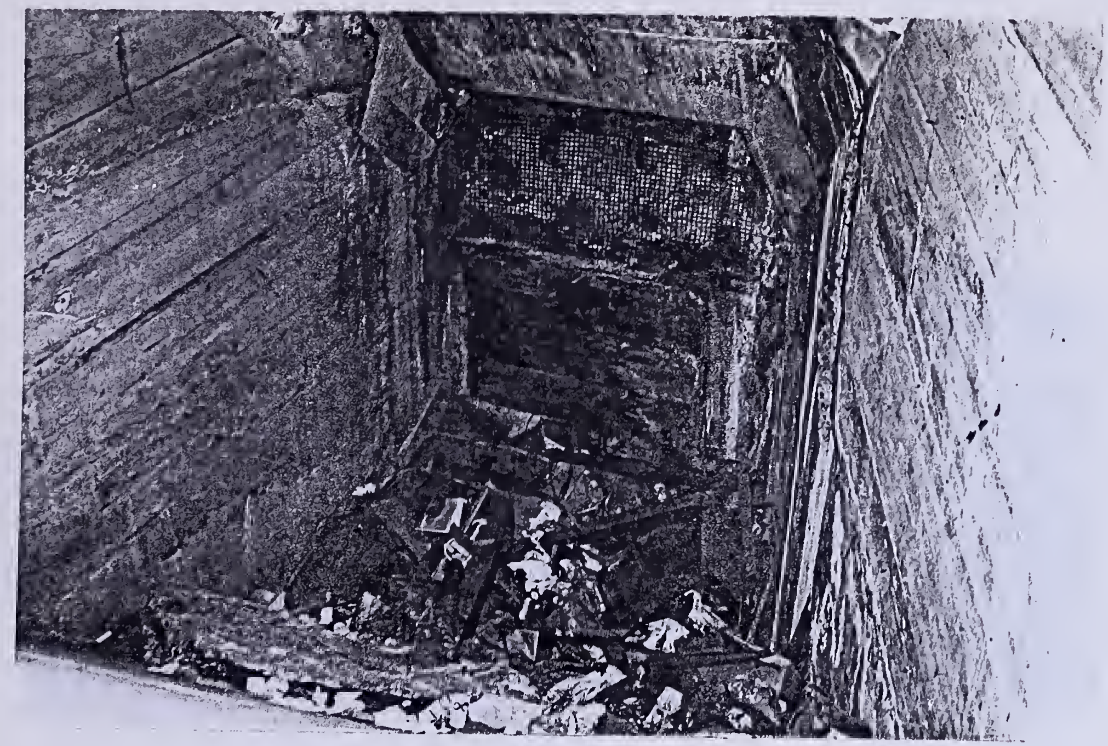
MAP INDEX: Q-27-41

MINE: West Gray Rock

SUBJECT: Shaft - Fan Incline

AERIAL PHOTO INDEX: P6 - 41

PAGE 1 OF 3



SAFETY HAZARD: The bottom of the decline or fan intake is bulkheaded from the shaft with timber. If a fire should start in the rubble at the bottom of the decline it would burn the bulkhead and allow direct entrance into the shaft. This situation is extremely dangerous with the shaft being 1800 feet deep and unfilled. The area is in close proximity to residences and an attraction to children.

HEALTH HAZARD: A fire started in the rubble would produce smoke and be highly dangerous to the health of anyone in the confined area.

HEALTH HAZARD FACTOR: 3

SAFETY HAZARD FACTOR: 5

MISCELLANEOUS COMMENTS:

AREA: Walkerville

VIEW: Looking Easterly

PHOTO NEGATIVE INDEX: G3 - 11

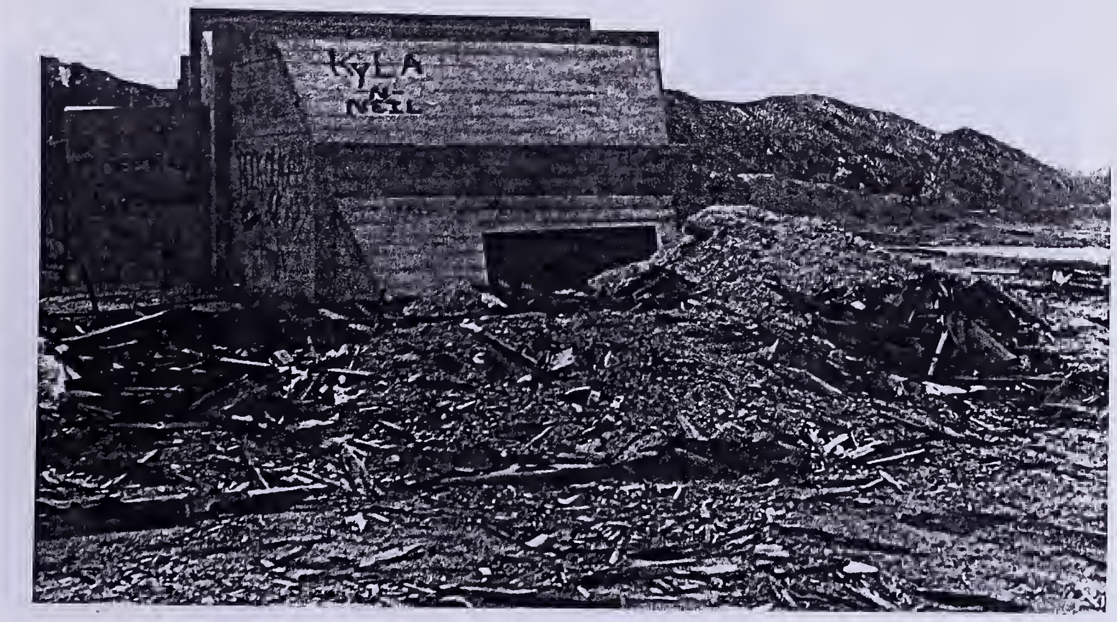
MAP INDEX: Q-27-42

MINE: West Gray Rock

SUBJECT: Shaft collar - rubble-pile

AERIAL PHOTO INDEX: P6 - 42

PAGE 2 OF 3



HEALTH HAZARD: Rubble and junk scattered about the area is a health hazard to children playing in the vicinity.

SAFETY HAZARD: The shaft appears to be bulkheaded on the surface and covered with some waste material. The shaft was used as a ventilation exhaust opening and is 1800 feet deep. The old foundations andshaft collar are open to the public. Due to the poor method of protecting the collar of the shaft, the area is potentially dangerous particularly as it has no protection from the public, such as, fences or barriers. The wood bulkhead on the collar will eventaully cave creating an extremely hazardous situation.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 5

MISCELLANEOUS COMMENTS:

AREA: Walkerville

VIEW: Looking South

PHOTO NEGATIVE INDEX: G3 - 17

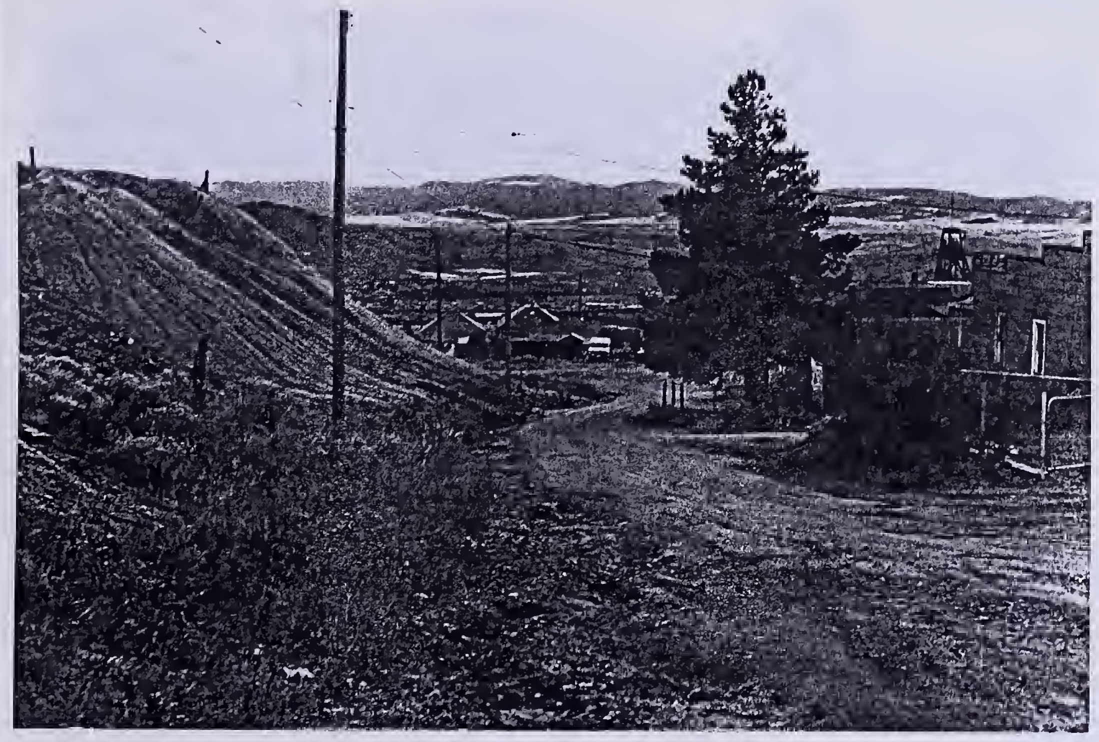
MAP INDEX: Q-27-43

MINE: West Gray Rock

SUBJECT: Waste Dump

AERIAL PHOTO INDEX: P6 - 43

PAGE 3 OF 3



SAFETY HAZARD: No real safety hazard other than children playing on the steep dump slopes,

HEALTH HAZARD: The drainage from the dumps, which is slightly acid, is not contained and flows down the street creating a potential health hazard.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 1

MISCELLANEOUS COMMENTS:

AREA: Walkerville

VIEW: Looking South

PHOTO NEGATIVE INDEX: G4 - 17

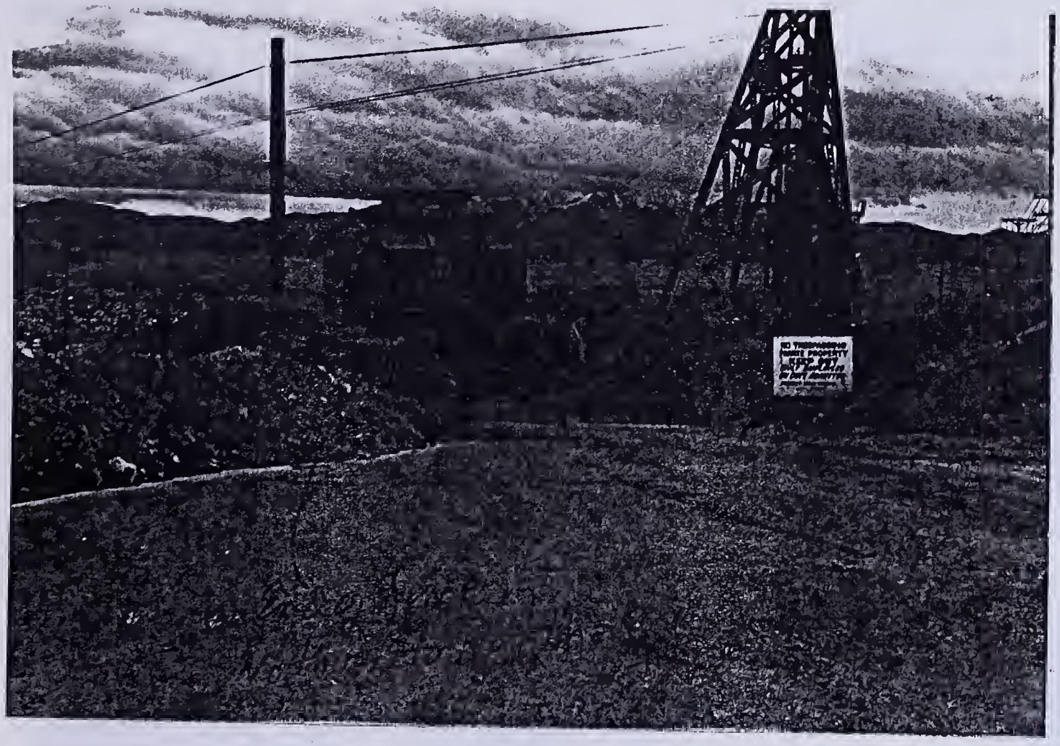
MAP INDEX: Q-27-32

MINE: Diamond

SUBJECT: Diamond headframe and North-end of fence

AERIAL PHOTO INDEX: P5 - 32

PAGE 1 OF 3



SAFETY HAZARD: This is the end of the Anaconda Security fence. Evidence of motorcycles and vehicles entering the mining area around this gate. This permits access into the Berkeley Pit, tailings ponds, etc.

HEALTH HAZARD: N/A

HEALTH HAZARD FACTOR: N/A

SAFETY HAZARD FACTOR: 5

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Walkerville

VIEW: Looking Southerly

PHOTO NEGATIVE INDEX: G17-9a

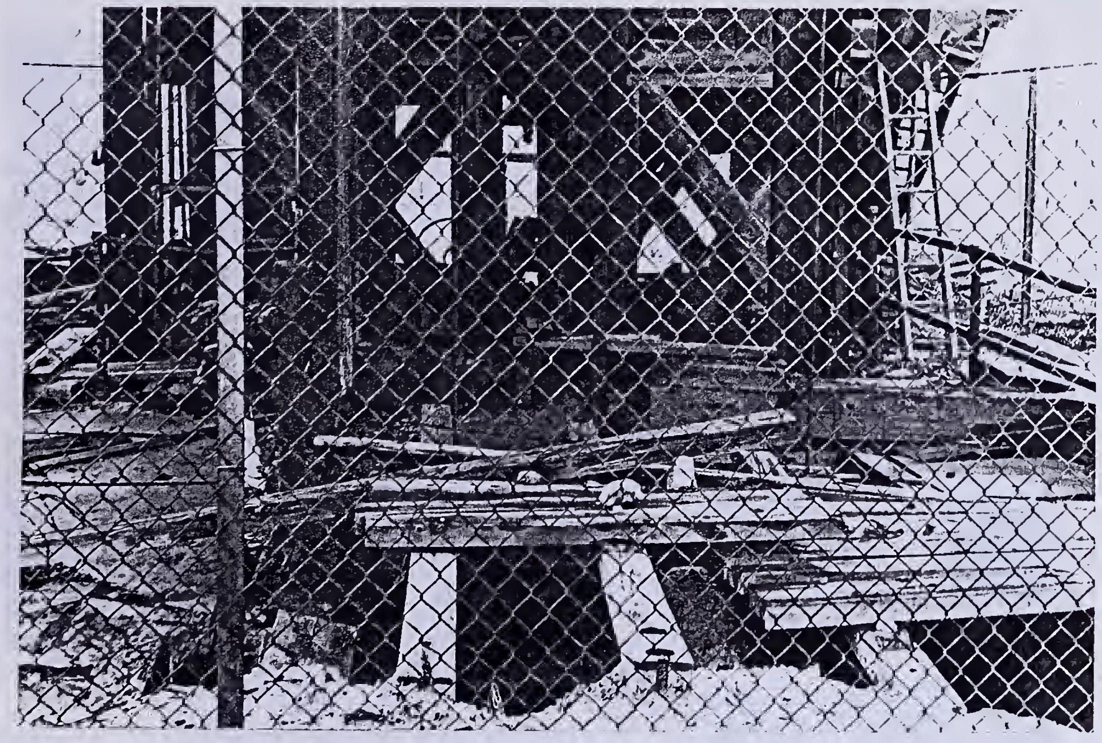
MAP INDEX: Q-27-159

MINE: Diamond

SUBJECT: Shaft

AERIAL PHOTO INDEX: P6-159

PAGE 2 OF 3



HEALTH HAZARD: "Bad air" could be rising up the shaft creating a very dangerous health hazard particularly if a person fell into the subsurface structure which is entirely open.

SAFETY HAZARD: The surface structure has been removed. It is reported that the shaft timber has caved to 40 feet below surface. A fence that can be easily scaled surrounds the shaft area. The area is vulnerable to the public and is extremely dangerous. No bulkhead exists in the shaft.

HEALTH HAZARD FACTOR: 3

SAFETY HAZARD FACTOR: 5+

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Walkerville

VIEW: Looking Westerly

PHOTO NEGATIVE INDEX: G17-11a

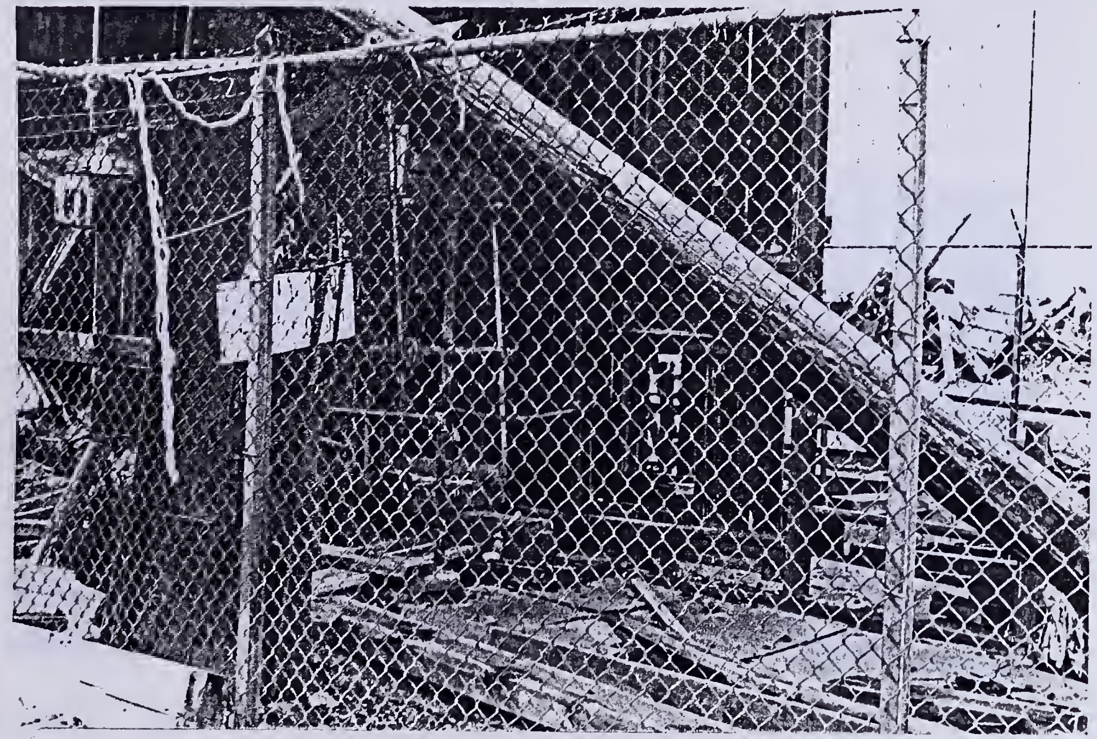
MAP INDEX: Q-27-160

MINE: Diamond

SUBJECT: Shaft

AERIAL PHOTO INDEX: P6-160

PAGE 3 OF 3



SAFETY HAZARD: Photo shows the condition of the surface.

HEALTH HAZARD: Same as page 1

HEALTH HAZARD FACTOR:

SAFETY HAZARD FACTOR: 5+

MISCELLANEOUS COMMENTS:

AREA: Walkerville

VIEW: Looking Northerly

PHOTO NEGATIVE INDEX: G4 - 21

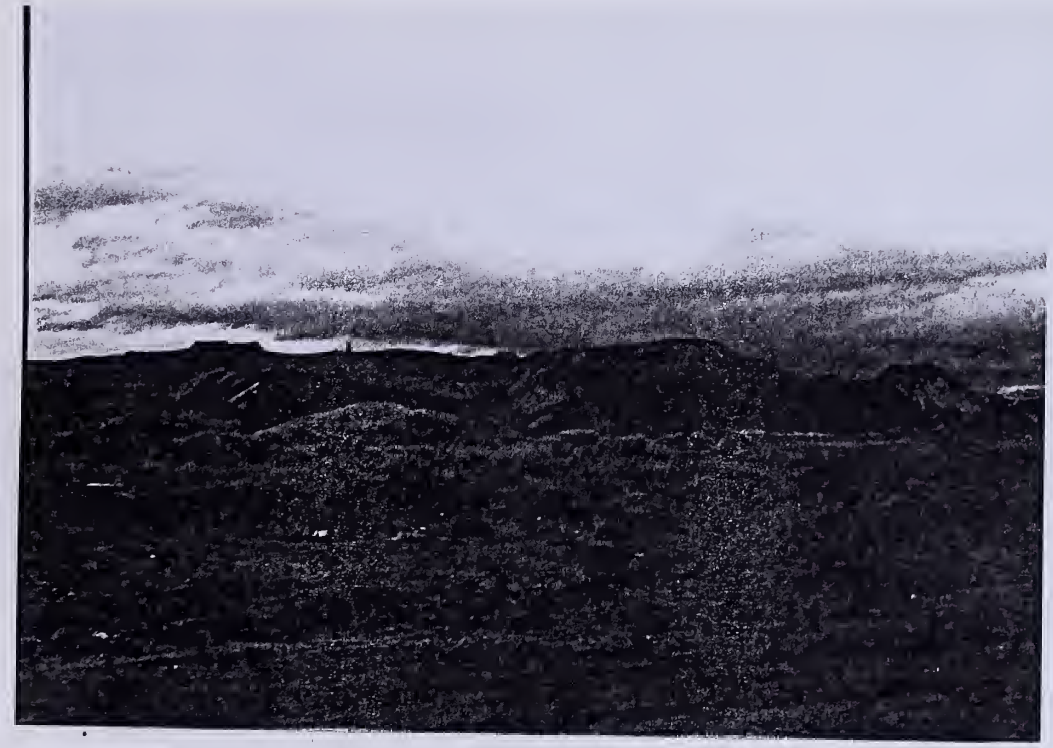
MAP INDEX: Q-27-31

MINE: Moose Area

SUBJECT: Stockpiles

AERIAL PHOTO INDEX: P5 - 31

PAGE 1 OF 1



HEALTH HAZARD: This photograph shows stockpiles of "black manganese" ore. The piles are very acidic and may present a water contamination problem.

SAFETY HAZARD: None

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 1

MISCELLANEOUS COMMENTS:

AREA: Walkerville

VIEW: Looking Northeasterly

PHOTO NEGATIVE INDEX: G4 - 3

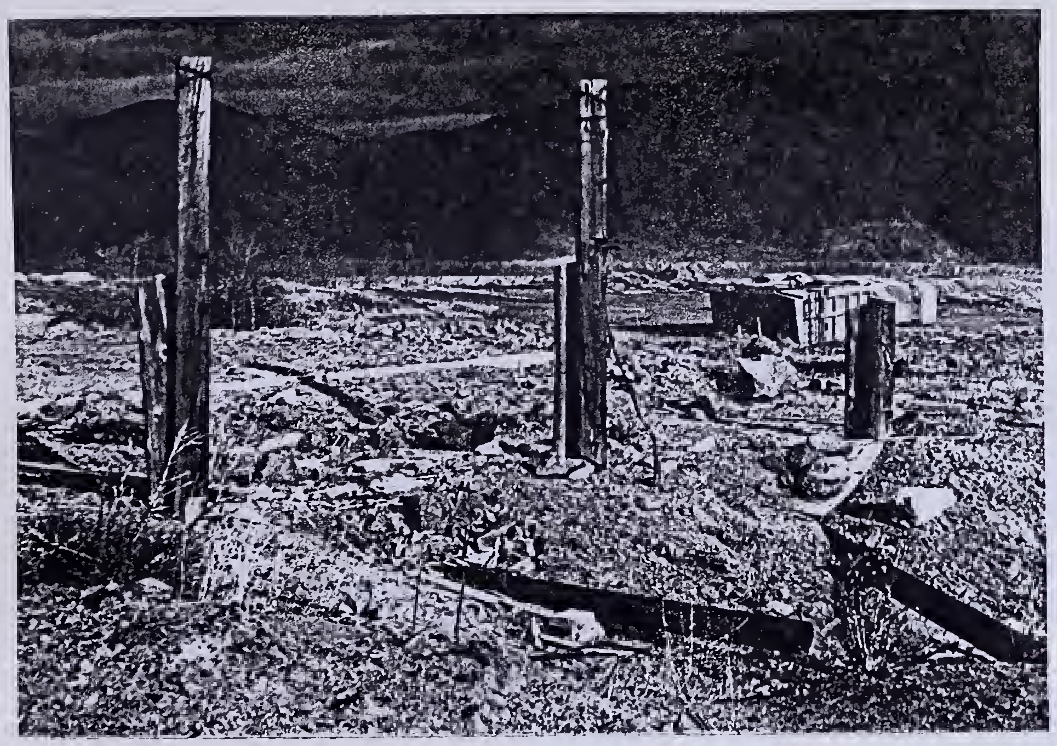
MAP INDEX: Q-27-24

MINE: Moose

SUBJECT: Shaft Collar

AERIAL PHOTO INDEX: P5 - 24

PAGE 1 OF 3



SAFETY HAZARD: The moose shaft was bulkheaded with timber and then buried with rock on the surface. The shaft was bulkheaded within the last 5 years. The shaft is 2000' deep vertically plus an additional 1900' on incline. The shaft collar is not recognizable on surface at this time and the area is open to the public. Due to the poor methods used to seal the shaft, it is now a potentially dangerous area. The wood bulkhead will eventually fail causing an extremely hazardous situation.

HEALTH HAZARD: Barren waste dumps and piles of scrap iron, etc. open to the public.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 4

MISCELLANEOUS COMMENTS:

AREA: Walkerville

VIEW: Looking Northerly

PHOTO NEGATIVE INDEX: G4 -4

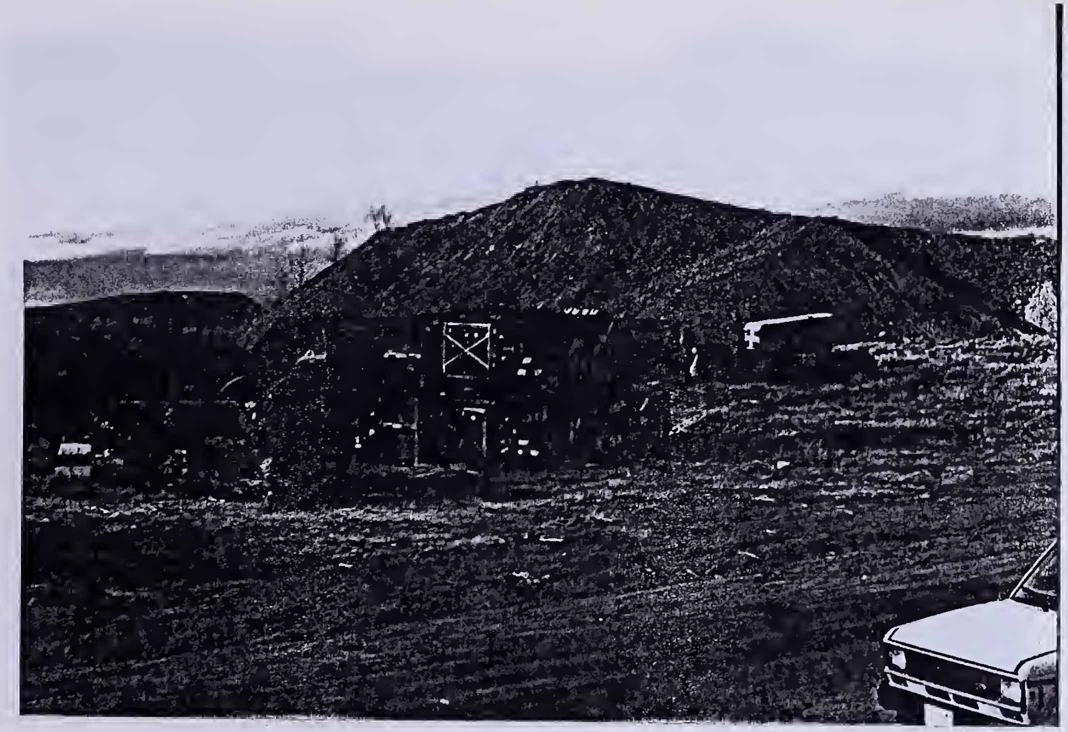
MAP INDEX: Q-27-25

MINE: Moose

SUBJECT: Moosewaste Dump with old rubble

AERIAL PHOTO INDEX: P5 - 25

PAGE 2 OF 3



SAFETY HAZARD: Undetermined

HEALTH HAZARD: Barren spoil pile subject to wind erosion and dusting. Acid composition of waste material. Old cages and skips shown in the foreground,- Rusty with sharp edges. Open to the public.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 1

MISCELLANEOUS COMMENTS:

AREA: Walkerville

VIEW: Looking South

PHOTO NEGATIVE INDEX: G4 - 5

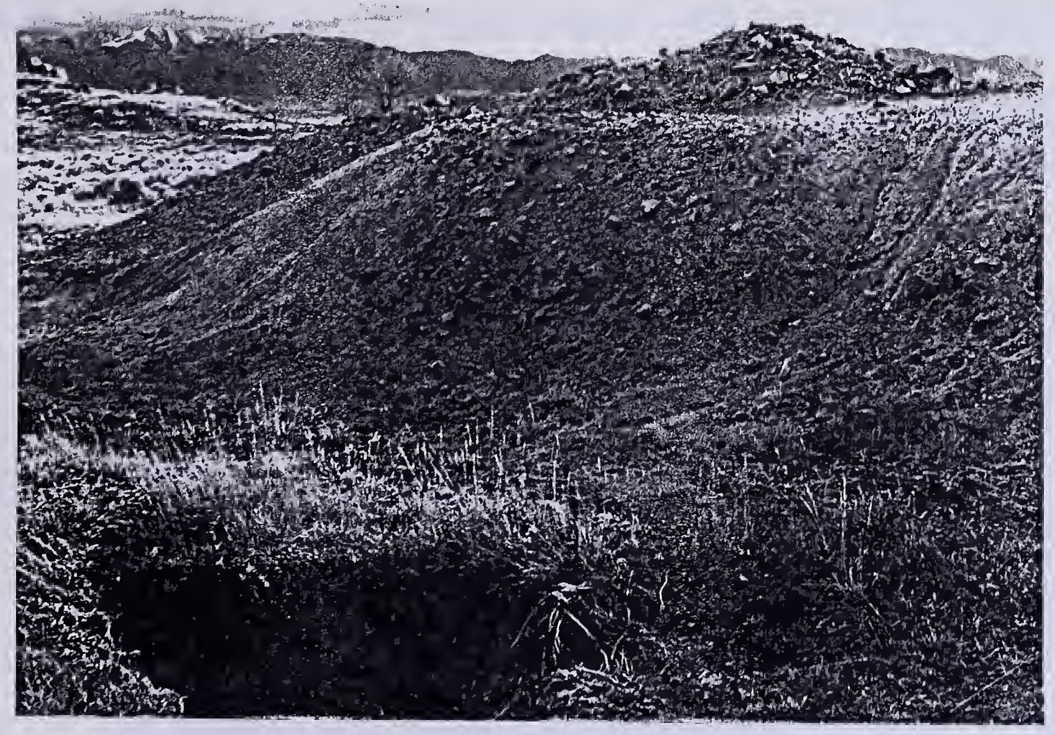
MAP INDEX: Q-27-28

MINE: Moose (Auraria shaft)

SUBJECT: Small opening near Moose

AERIAL PHOTO INDEX: P5 - 28

PAGE 3 OF 3



SAFETY HAZARD: The hole shown in the foreground is a very recent subsidence of the Auraria shaft. The shaft is of unknown depth and is subject to further caving, possibly producing a dangerous condition. This type of subsidence is typical of bulkheaded shafts that can cave at virtually any moment.

HEALTH HAZARD: Barren spoil pile

HEALTH HAZARD FACTOR: 1

SAFETY HAZARD FACTOR: 3

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Walkerville

VIEW: Looking Southeasterly

PHOTO NEGATIVE INDEX: G4 -7

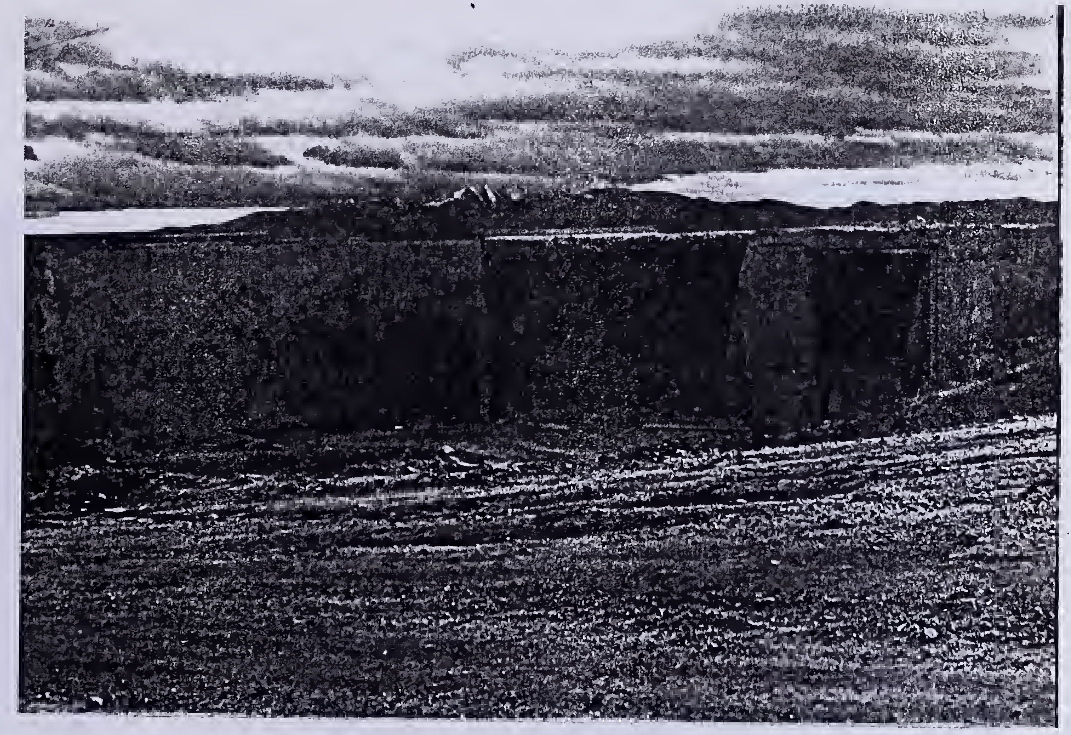
MAP INDEX: Q-27-29

MINE: Corra

SUBJECT: Old Fan House - Corra #2

AERIAL PHOTO INDEX: P5 - 29

PAGE 1 OF 2



SAFETY HAZARD: This shaft was used as a ventilation exhaust opening. The concrete structure shown was the duct work for the ventilation system as well as the fan foundation. The shaft is 2800' deep and supposedly filled. However, the shaft condition is questionable and should be regarded as moderately dangerous. The area is not near residences but due to the questionable condition shaft protection it is rated at a safety hazard of 3.

HEALTH HAZARD: Exposed embedded metal bolts, etc. and deteriorated concrete structure present.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 3

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Walkerville

VIEW: Looking Southwesterly

PHOTO NEGATIVE INDEX: G4-8, 9, & 10

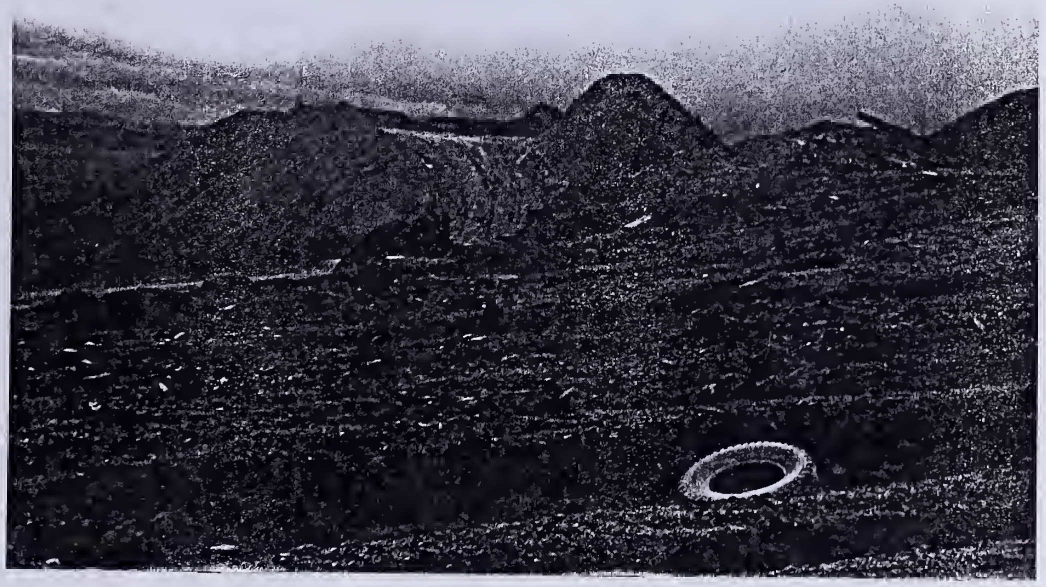
MAP INDEX: Q-27-30

MINE: Corra

SUBJECT: Panorama of Corra and Waste Dump

AERIAL PHOTO INDEX: P5 - 30

PAGE 2 **OF** 2



HEALTH HAZARD: Barren spoil pile exposed to wind and rain erosion. Embedded wood and sharp metal scrap. Acid composition of dump has prevented revegetation.

SAFETY HAZARD: Steep-walled dump - open to the public. The area is not fenced and is open to the public.

HEALTH HAZARD FACTOR: 3

SAFETY HAZARD FACTOR: 1

MISCELLANEOUS COMMENTS:

AREA: Walkerville

VIEW: Looking Northeasterly from west edge of pit

PHOTO NEGATIVE INDEX: G1 - 15

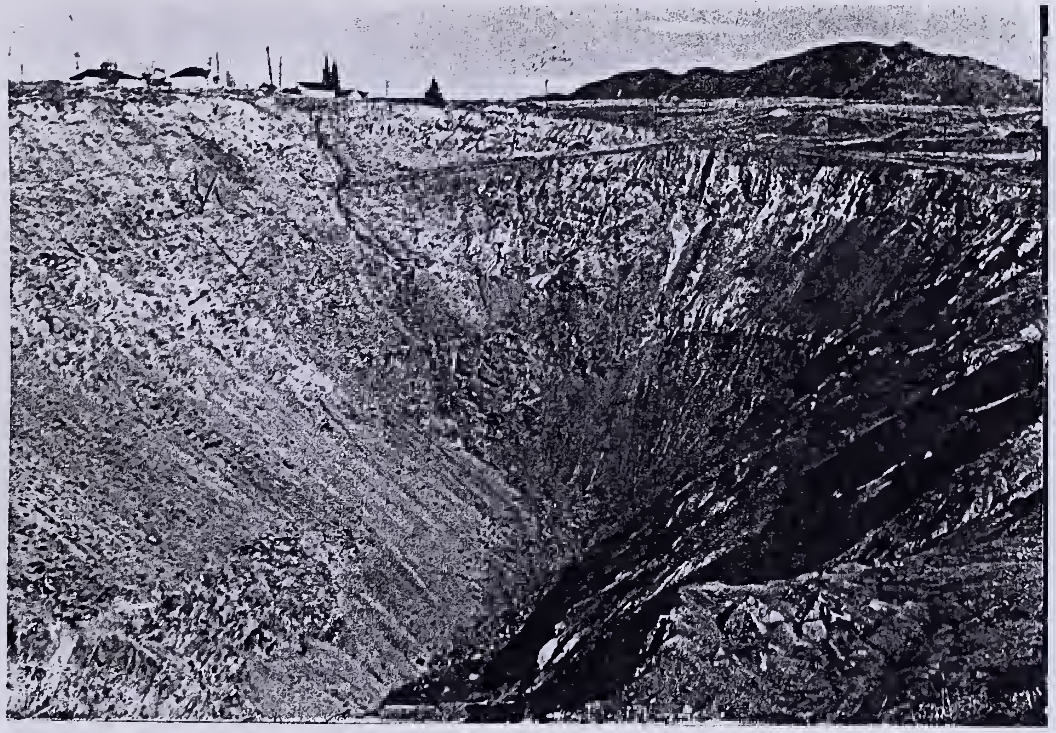
MAP INDEX: Q-23-06

MINE: Alice Pit

SUBJECT: North, East & South walls of pit

AERIAL PHOTO INDEX: P5 - 06

PAGE 1 OF 6



SAFETY HAZARD: Dangerous steep-walled open pit. Walls will continue to subside. Two to three hundred foot en scarpments. This area is vulnerable to local residents who use the area as motorcycle and bicycle trails as well as pedestrian routes. The trails in many area are located a few feet from the exscarpment edge. The area is not fenced on the west and south boundaries.

HEALTH HAZARD: Dusty conditions due to barren exposed surfaces. No mine water drainage.

EALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 5

ISCELLANEOUS COMMENTS:

AREA: Walkerville

VIEW: Looking Southeasterly from west edge of pit

PHOTO NEGATIVE INDEX: G1 - 12

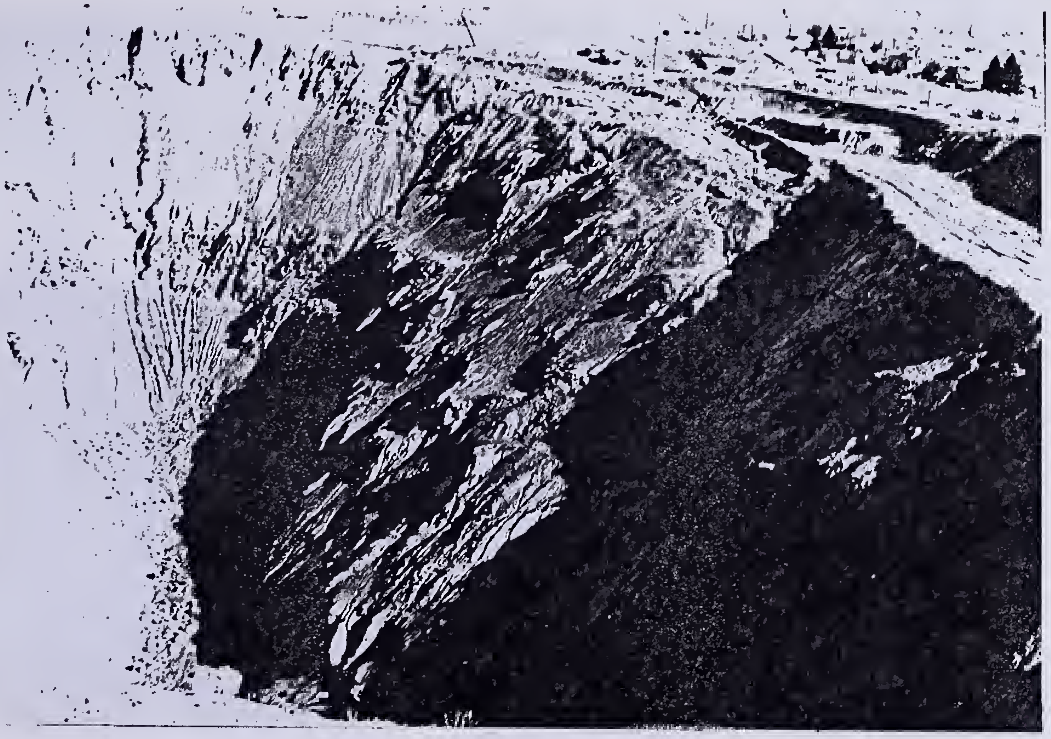
MAP INDEX: Q-23-07

MINE: Alice Pit

SUBJECT: South wall of pit

AERIAL PHOTO INDEX: P5 - 07

PAGE 2 OF 6



SAFETY HAZARD: The same hazards as page 1. Note steep south wall that is definitely unstable and unprotected. Given time, the pit walls will collapse to the natural angle of repose of approximately 38°. The present pit walls as shown are approximately 65° to 70°. Therefore, the walls have an immediate potential of subsiding approximately 100 feet from the existing edge.

HEALTH HAZARD: Same as page 1.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 5

MISCELLANEOUS COMMENTS:

AREA: Walkerville

VIEW: Looking Southerly

PHOTO NEGATIVE INDEX: G1 - 11

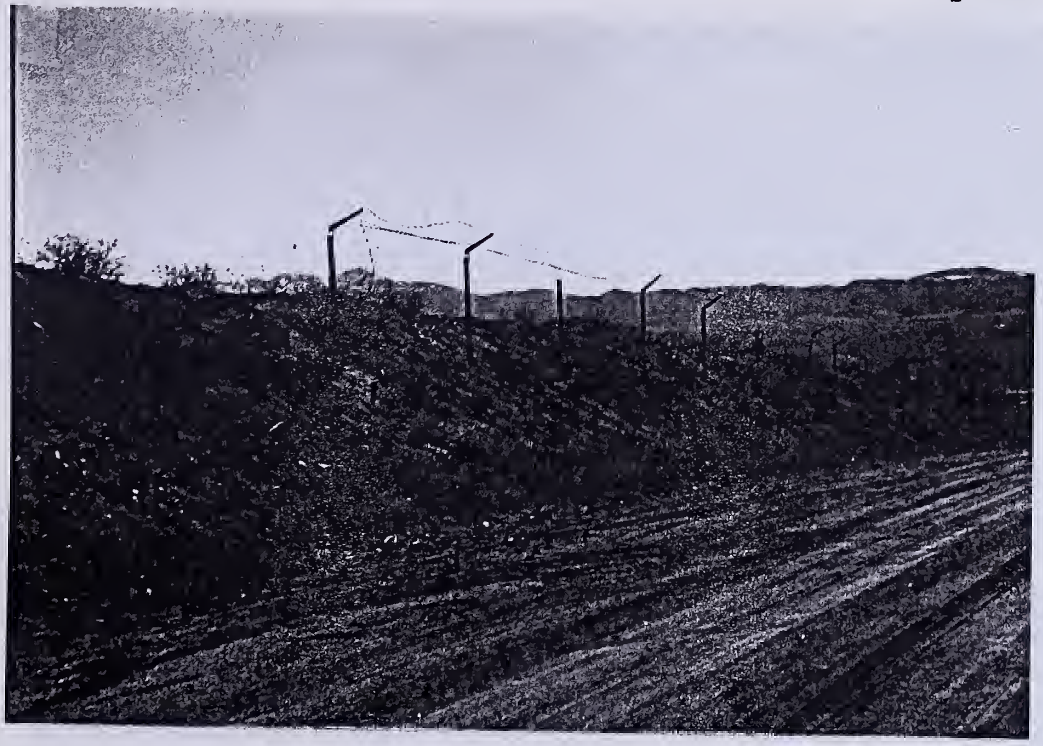
MAP INDEX: Q-23-08

MINE: Alice Pit

SUBJECT: Missing fence - west side of pit

AERIAL PHOTO INDEX: P5 - 08

PAGE 3 OF 6



SAFETY HAZARD: View showing the west fence of the Alice Pit area with wire removed.

HEALTH HAZARD: N/A

HEALTH HAZARD FACTOR: N/A

SAFETY HAZARD FACTOR: 5

MISCELLANEOUS COMMENTS:

AREA: Walkerville

VIEW: Looking Northerly from corner of Main & Daly Sts.

PHOTO NEGATIVE INDEX: G1 - 9

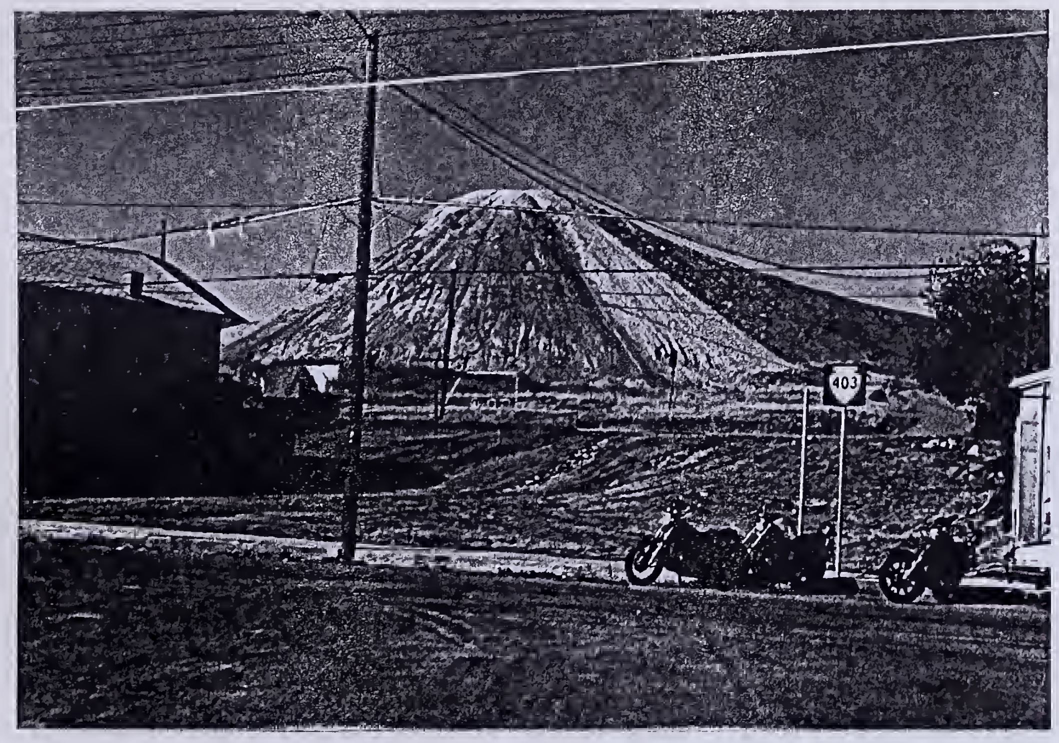
MAP INDEX: Q-27-09

MINE: Alice Pit

SUBJECT: Alice Pit south waste dump

AERIAL PHOTO INDEX: P5 - 09

PAGE 4 OF 6



HEALTH HAZARD: Barren spoil pile causing severe dusting problems as well as water erosion. Dump is composed of slightly acidic waste material.

SAFETY HAZARD: Steep-walled dump open to the public.

HEALTH HAZARD FACTOR: 2.5

SAFETY HAZARD FACTOR: 2

MISCELLANEOUS COMMENTS:

AREA: Walkerville

VIEW: Looking Southeasterly

PHOTO NEGATIVE INDEX: 18 G1 -18

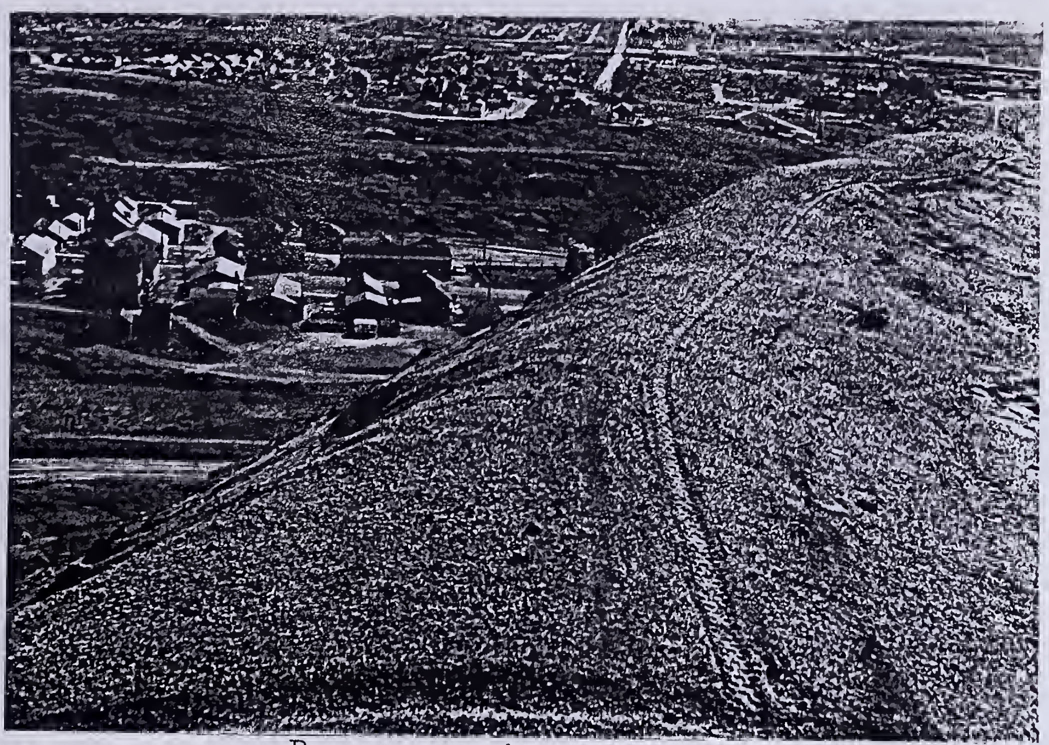
MAP INDEX: Q-23-10

MINE: Alice Pit

SUBJECT: Top of Alice Pit West waste dump

AERIAL PHOTO INDEX: P5 - 10

PAGE 5 OF 6



SAFETY HAZARD: Steep-walled dump 200 ft. high with no berm protection on top. Road up to the top is inadequately blocked to prevent automobile traffic. Note motorcycle track along edge of dump.

HEALTH HAZARD: Barren spoil pile causing dusting problems. No vegetation due to steep walls and acid composition of the waste material.

HEALTH HAZARD FACTOR: 2.5

SAFETY HAZARD FACTOR: 4

MISCELLANEOUS COMMENTS:

REA: Walkerville

VIEW: Looking Easterly

PHOTO NEGATIVE INDEX: G1 - 21

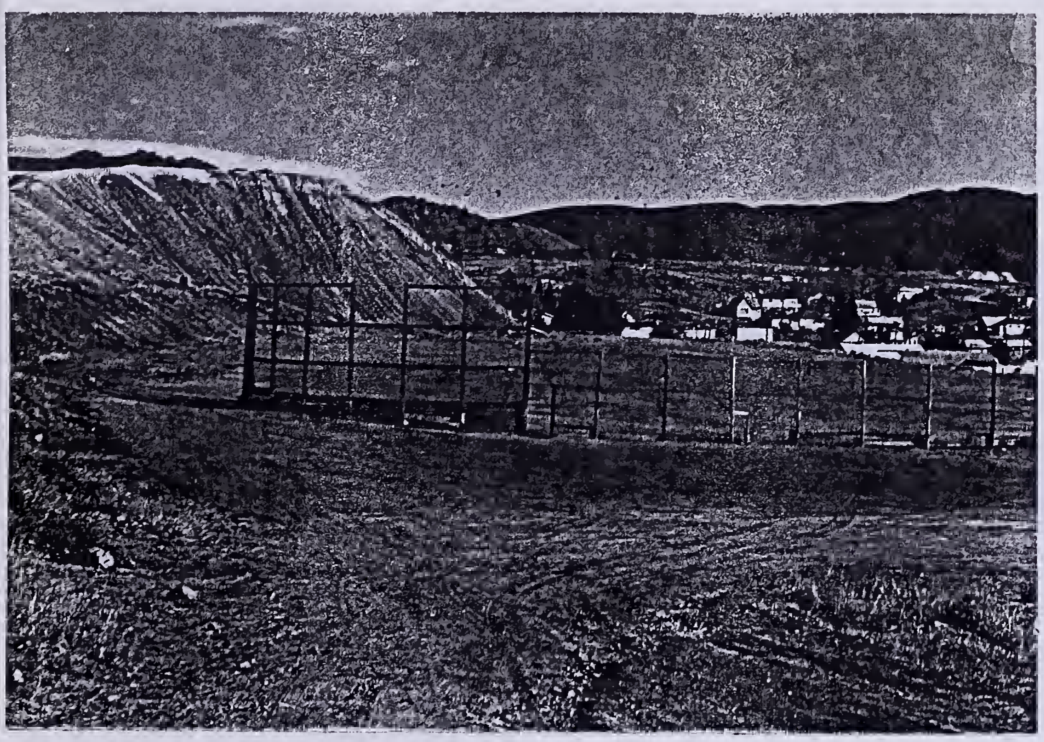
MAP INDEX: Q-23-11

INE: Alice Pit

SUBJECT: Playground - south side of Pit

AERIAL PHOTO INDEX: P5 - 11

PAGE 6 OF 6



EALTH HAZARD: Barren spoil pile causing dusting problems adjacent to the playground.

SAFETY HAZARD: Playground adjoining the Alice Pit. There is no fence between the playground and the south wall of the pit, shown on page 2. Extremely dangerous condition for children.

EALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 5

ISCELLANEOUS COMMENTS:

AREA: Walkerville

VIEW: Looking South

PHOTO NEGATIVE INDEX: G4 - 11

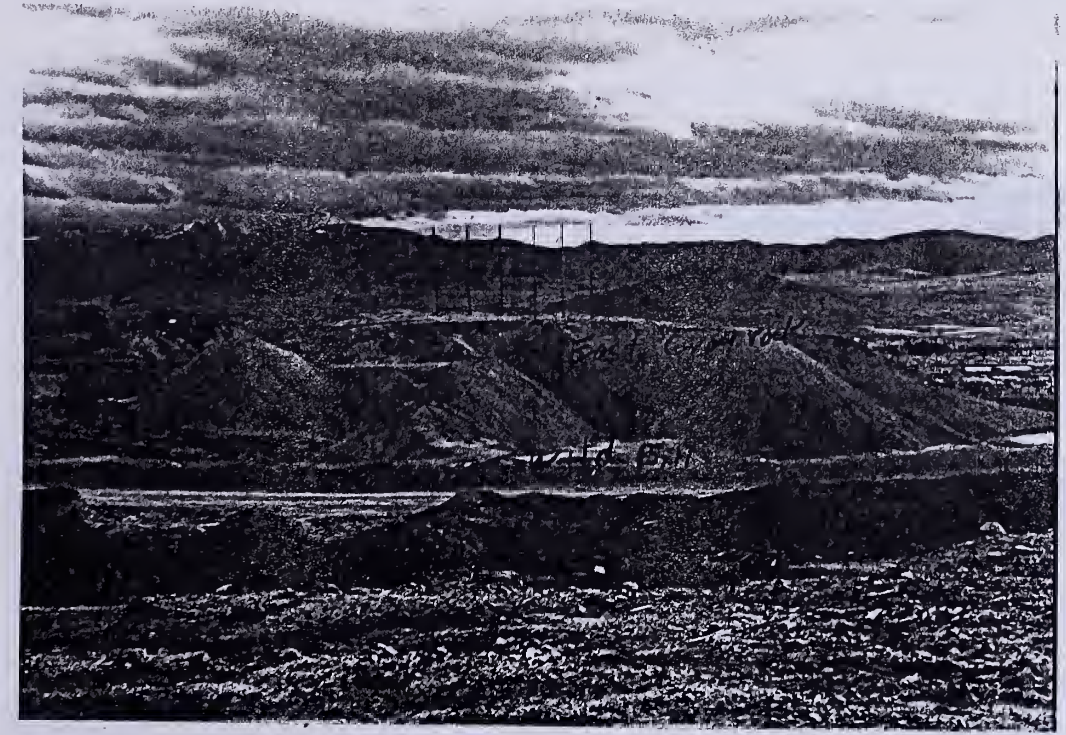
MAP INDEX: Q-27-33

MINE: East Gray Rock

SUBJECT: Wild Bill & East Gray Rock

AERIAL PHOTO INDEX: P5 - 33

PAGE 1 OF 1



EALTH HAZARD: Barren spoil pile subject to dusting. Scrappiles of sharp metal and wood are located to the left. Dump material is acidic preventing vegetation.

SAFETY HAZARD: The Wild Bill Shft is filled and not a hazard. The East Gray Rock dumps shown are steep-walled and open to the public. The East Gray Rock Shaft is bulkheaded on the surface but inside existing chain link fencing.

EALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 2

ISCELLANEOUS COMMENTS:

AREA: Walkerville

VIEW: Looking Southeast

PHOTO NEGATIVE INDEX: G6 - 3

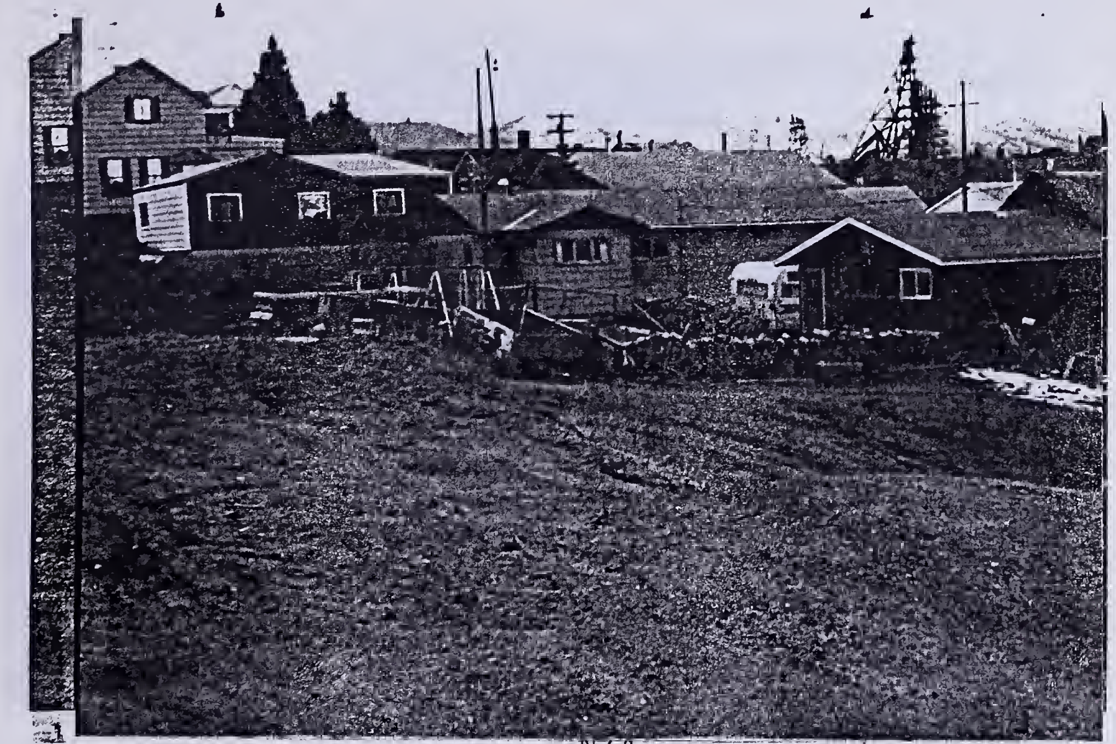
MAP INDEX: Q-23

MINE: Paymaster Lease

SUBJECT: Shaft Location

AERIAL PHOTO INDEX: P5 - 20

PAGE 1 OF 2



SAFETY HAZARD: The shaft collar is located in the yard as shown on the photo. It was likely bulkheaded with timber a short distance below the surface and covered with waste material. The bulkhead will fail at some time causing an extremely dangerous situation. The shaft is 300 ft. deep and if the surface cover failed could cause the adjacent house to be in jeopardy.

HEALTH HAZARD: N/A

HEALTH HAZARD FACTOR: 1

SAFETY HAZARD FACTOR: 3

MISCELLANEOUS COMMENTS:

AREA: Walkerville

VIEW: Looking East

East

PHOTO NEGATIVE INDEX: G6 - 2

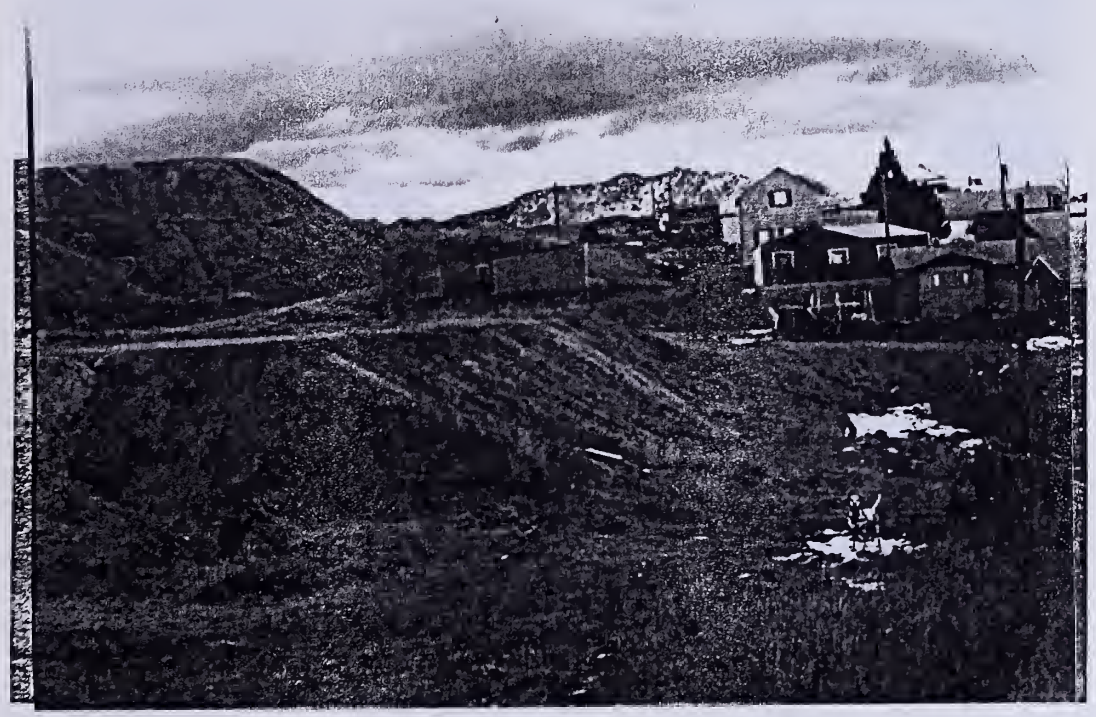
MAP INDEX: Q - 23

MINE: Paymaster Lease

SUBJECT: Shaft Location & Dump

AERIAL PHOTO INDEX: P5 - 21

PAGE 2 OF 2



SAFETY HAZARD: N/A

HEALTH HAZARD: The dump is slightly acid and dust blown from the dump could be a health hazard. The close proximity to residences makes a greater health hazard to the public.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 1

MISCELLANEOUS COMMENTS:

AREA: Walkerville

VIEW: At shaft - Looking West

PHOTO NEGATIVE INDEX: G1 - 22

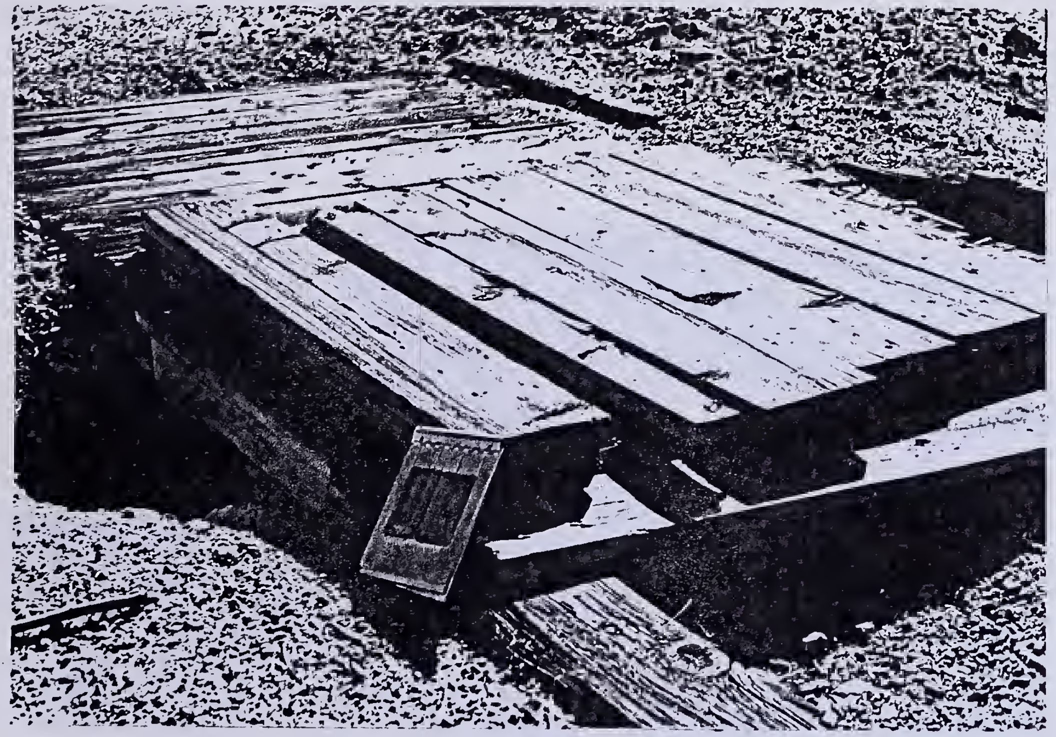
MAP INDEX: Q-23-01

MINE: Rising Star (Lessee shaft #1

SUBJECT: Bulkhead failure on shaft

AERIAL PHOTO INDEX: P5 - 01

PAGE 1 OF 5



SAFETY HAZARD: The shaft of undetermined depth has caved at the surface. The bulkhead consists only of a double 3-inch board cover on the surface. The shaft is very vulnerable to children playing in the area.

HEALTH HAZARD: Undetermined - no apparent seepage
See Dump - Page 2

HEALTH HAZARD FACTOR: N/A

SAFETY HAZARD FACTOR: 4

MISCELLANEOUS COMMENTS:

REA: Walkerville

VIEW: Looking Westerly

PHOTO NEGATIVE INDEX: G1 - 23

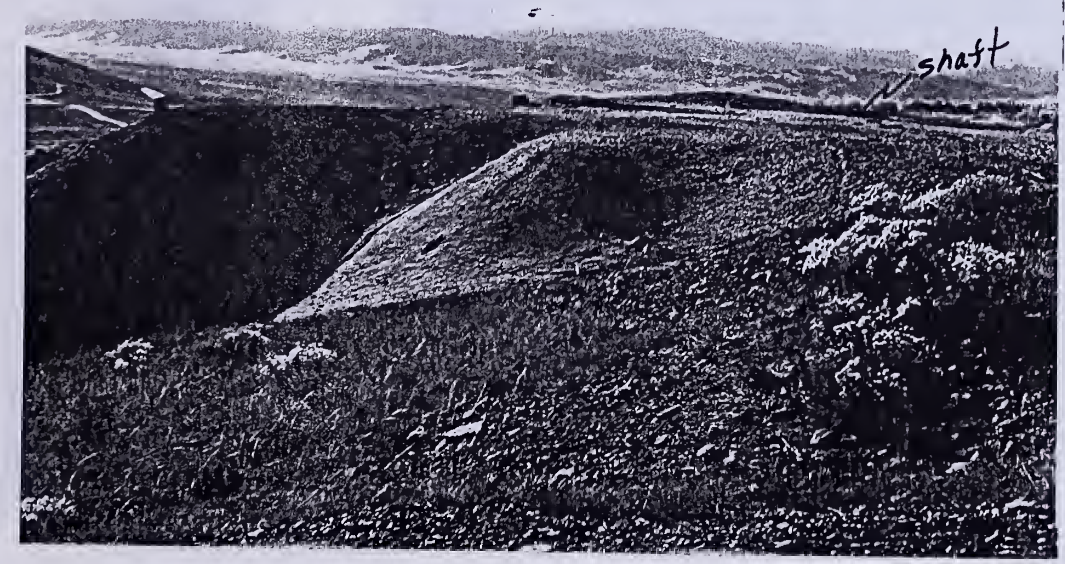
MAP INDEX: Q-23-02

INE: Rising Star (Lessee)

SUBJECT: Waste Dump

AERIAL PHOTO INDEX: P5 - 02

PAGE 2 OF 5



ALTH HAZARD: Waste spoil pile subject to wind erosion. No vegetation due to acid composition. No apparent seepage.

SAFETY HAZARD: Steep-walled dump

ALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 1

SCELLANEOUS COMMENTS:

AREA: Walkerville

VIEW: Looking Easterly

PHOTO NEGATIVE INDEX: G3 - 13

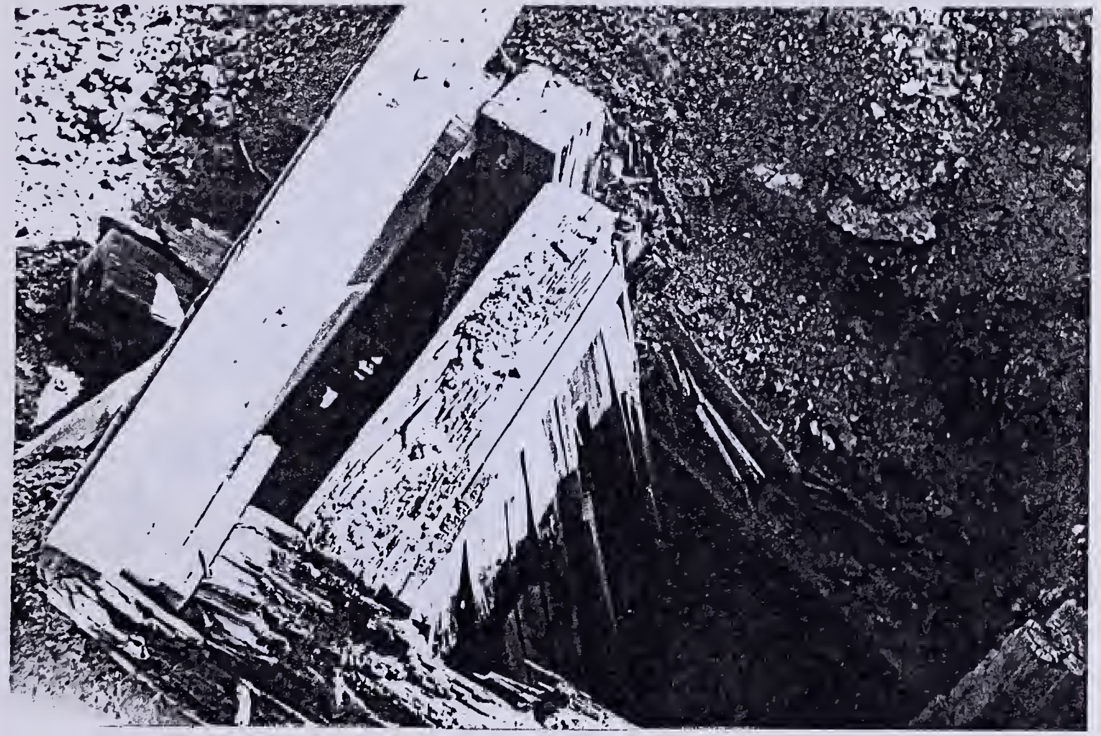
MAP INDEX: Q-23-03

MINE: Rising Star

SUBJECT: Lessee's shaft

AERIAL PHOTO INDEX: P6 - 03

PAGE 3 OF 5



SAFETY HAZARD: Open shaft of undetermined depth. Could not visually see the bottom. Surface bulkhead as failed. Extremely dangerous condition. Open to the public.

HEALTH HAZARD: Undetermined

HEALTH HAZARD FACTOR: 1

SAFETY HAZARD FACTOR: 4

MISCELLANEOUS COMMENTS:

AREA: Walkerville

VIEW: Looking Northerly

PHOTO NEGATIVE INDEX: G3 - 12

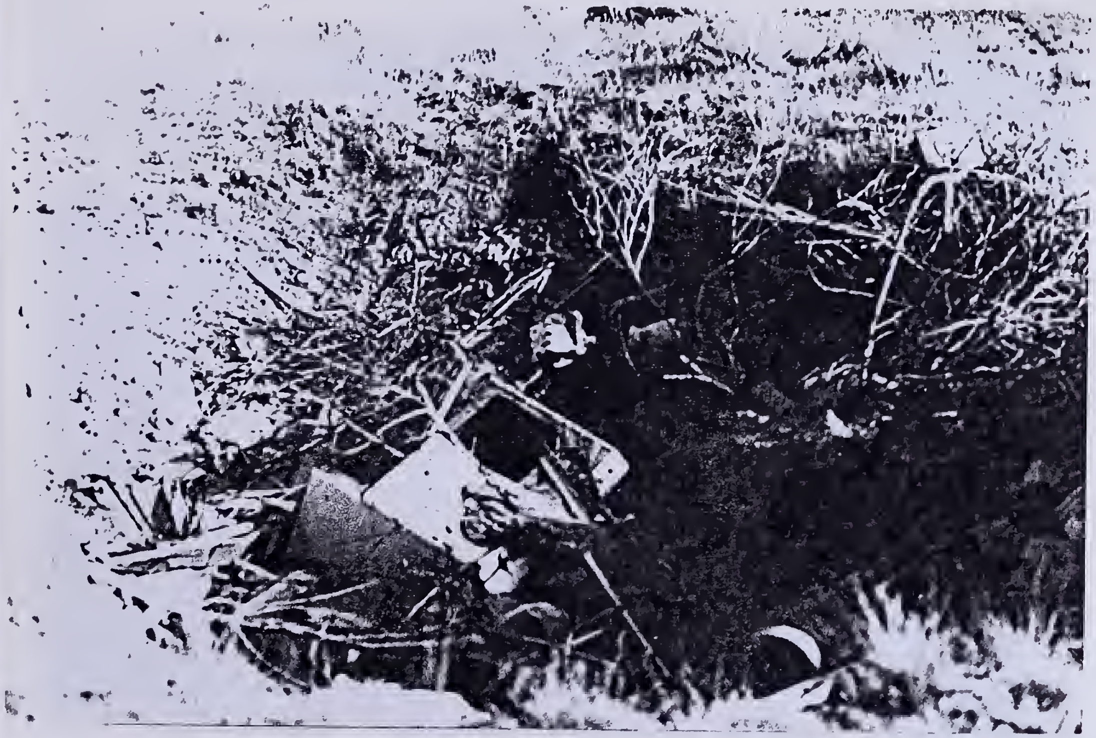
MAP INDEX: Q-23-04

MINE: Rising Star

SUBJECT: Main shaft - subsided

AERIAL PHOTO INDEX: P5 - 04

PAGE 4 OF 5



SAFETY HAZARD: The main shaft of undetermined depth has subsided to cause the depression shown in the photo. The shaft is probably 800 to 900 feet deep and therfore is likely to cave to a much greater extent. This would produce an extremely hazardous condition as the area is open to the public and is used as a play area for children.

HEALTH HAZARD: The subsided shaft area has been used as an unattended garbage dump. Sharp exposed metal and glass objects are scattered profusely.

HEALTH HAZARD FACTOR: 1.5

SAFETY HAZARD FACTOR: 3

MISCELLANEOUS COMMENTS:

AREA: Walkerville

VIEW: Looking Easterly

PHOTO NEGATIVE INDEX: G5 - 02

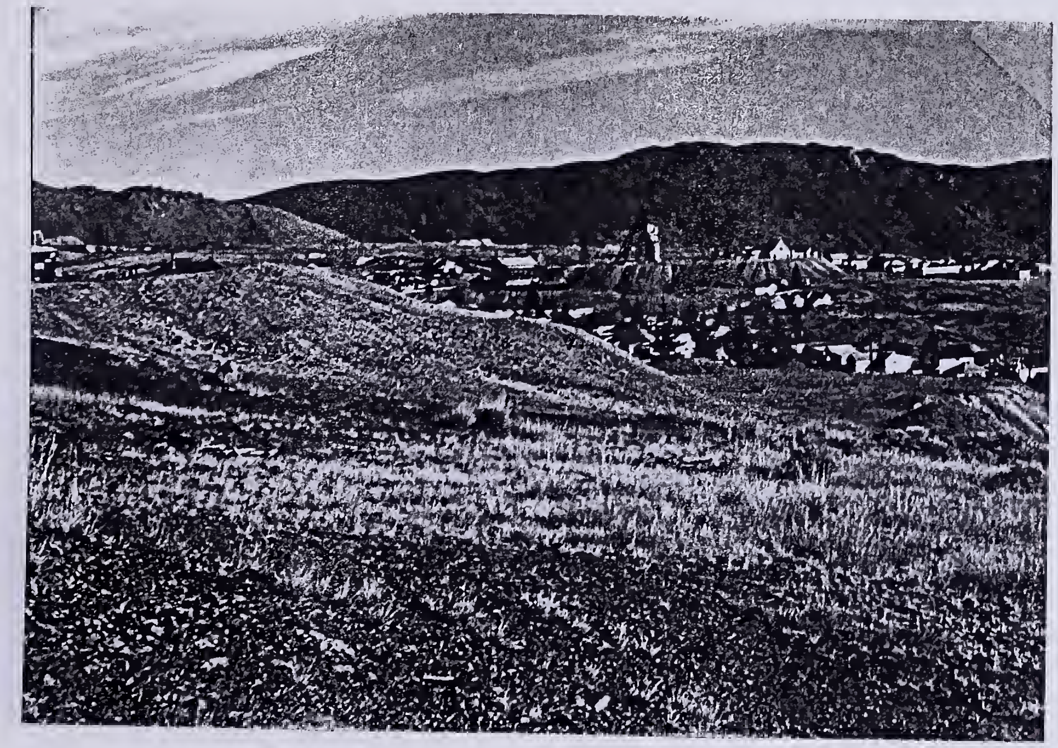
MAP INDEX: Q-23-34

MINE: Rising Star

SUBJECT: Main shaft waste dump

AERIAL PHOTO INDEX: P5 - 34

PAGE 5 OF 5



SAFETY HAZARD: Undertermined

HEALTH HAZARD: Open spoil pile subject to wind erosion. The pile is situated above the Walkerville area and is subject to rain erosion causing material to be transported toward the homes. Acid composition of the dump has prevented vegetation.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 1

MISCELLANEOUS COMMENTS:

AREA: Walkerville

VIEW: Looking South

PHOTO NEGATIVE INDEX: G5 - 5

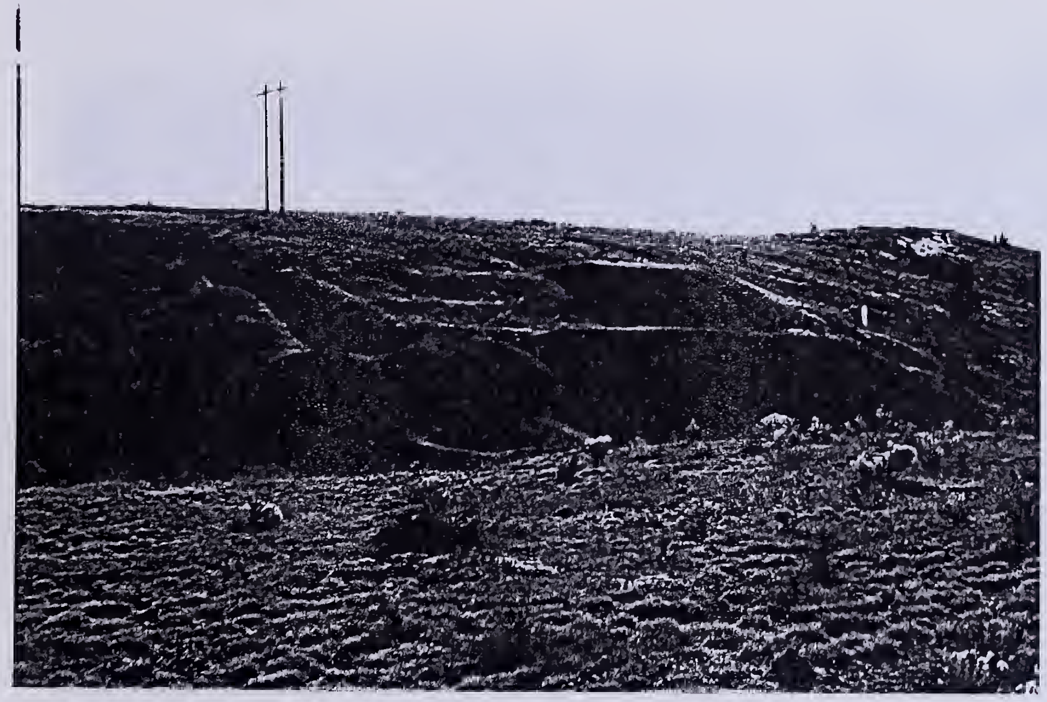
MAP INDEX: Q-23-19

MINE: Rising Star area

SUBJECT: Old tunnels & waste dumps

AERIAL PHOTO INDEX: P5 - 19

PAGE 1 OF 1



SAFETY HAZARD: Undetermined

HEALTH HAZARD: Many barren spoil piles subject to wind erosion.

HEALTH HAZARD FACTOR: 1.5

SAFETY HAZARD FACTOR: 1

MISCELLANEOUS COMMENTS:

AREA: Walkerville

VIEW: Looking Northwesterly from top of Alice West Dump

PHOTO NEGATIVE INDEX: G2 - 1A

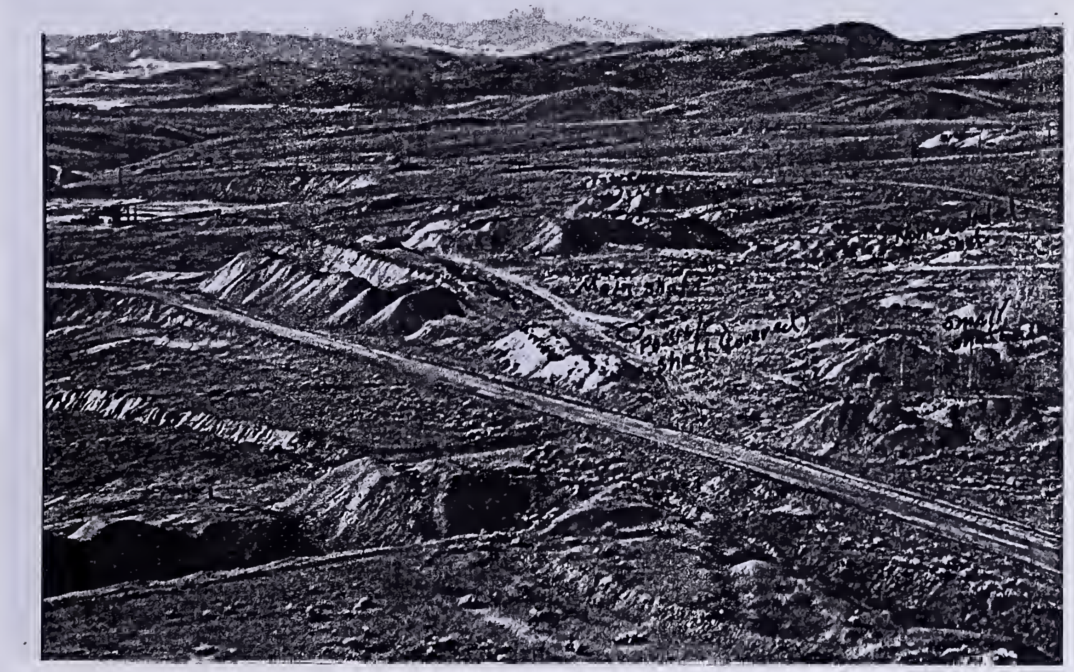
MAP INDEX: U-23-12

MINE: Goldsmith Group

SUBJECT: Goldsmith area

AERIAL PHOTO INDEX: P5 - 12

PAGE 1 OF 7



HEALTH HAZARD: See following six pages for detail- Index only

SAFETY HAZARD: See following six pages for detail - Index only

HEALTH HAZARD FACTOR:

SAFETY HAZARD FACTOR:

MISCELLANEOUS COMMENTS:

AREA: Walkerville

VIEW: Looking Northerly

PHOTO NEGATIVE INDEX: G2 - 8A

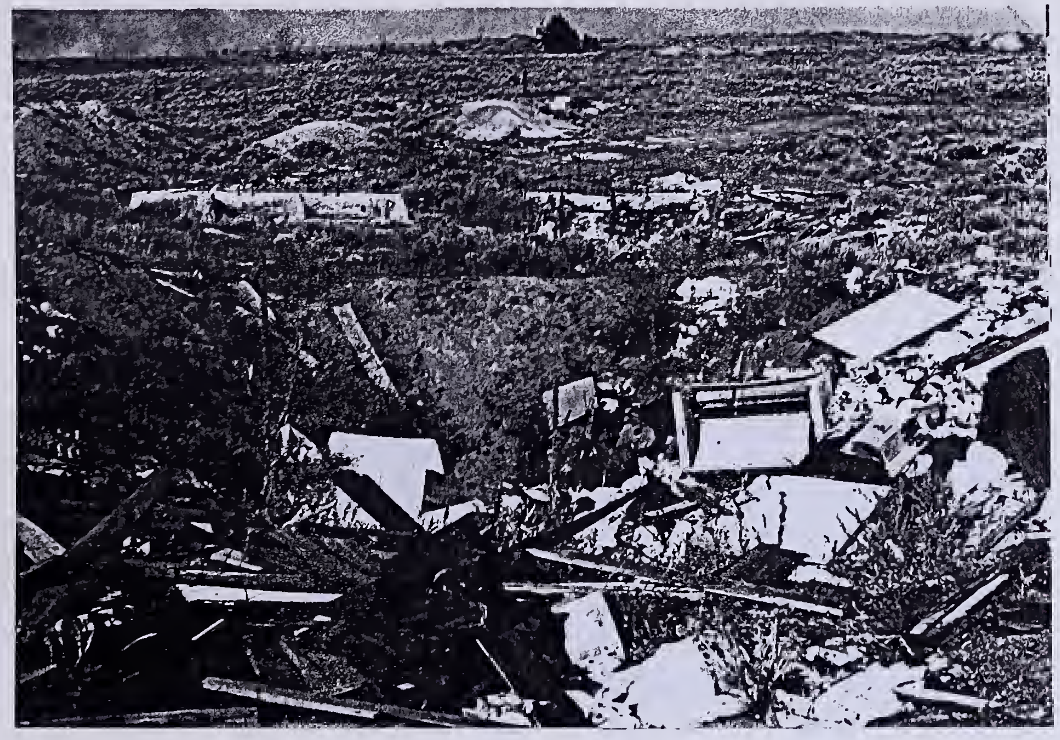
MAP INDEX: U-23-13

MINE: Goldsmith (Tong)

SUBJECT: Main shaft subsidence

AERIAL PHOTO INDEX: P5 - 13

PAGE 2 OF 7



SAFETY HAZARD: Shaft is 800 ft. deep and was probably bulkheaded many years ago. There is a reasonable possibility that the bulkhead will fail causing heavy subsidence and a deep open hole. This would result in an extremely dangerous condition as the area is open to the public.

HEALTH HAZARD: Unattended garbage dump located over shaft area. Sharp metal and glass objects, concrete hoist foundation in background with sharp imbedded anchor bolts. Area open to public. Area has evidence of children playing.

HEALTH HAZARD FACTOR: 3

SAFETY HAZARD FACTOR: 3

MISCELLANEOUS COMMENTS:

AREA: Walkerville

VIEW: Looking Northwesterly from main shaft location

PHOTO NEGATIVE INDEX: G2 - 10A

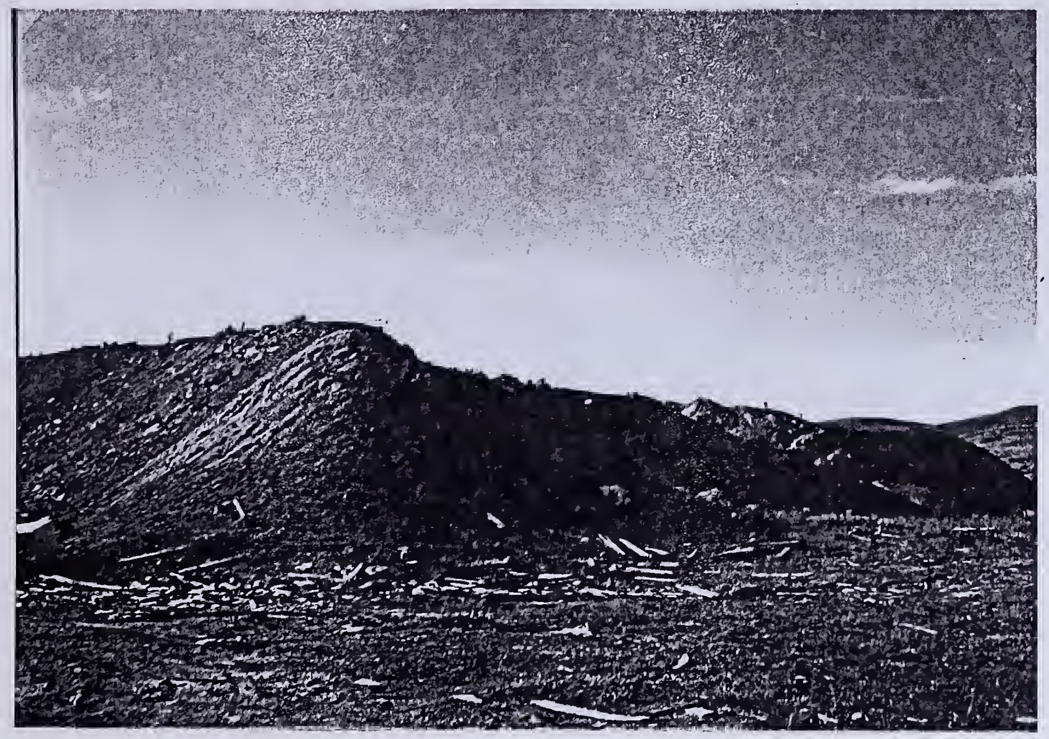
MAP INDEX: U-23-14

MINE: Goldsmith (Tong)

SUBJECT: Main Goldsmith Waste Dump

AERIAL PHOTO INDEX: P5 - 14

PAGE 3 OF 7



HEALTH HAZARD: Goldsmith dumps have recently been sampled by dozer cuts which removed the oxidized crust in many locations. These cuts are now vulnerable to wind and rain erosion. West wind dusting could be a hazard to Walkerville residents.

SAFETY HAZARD: Small, steep walled cuts and deep faces with exposed sharp metal and glass garbage. Open to the public.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 1

MISCELLANEOUS COMMENTS:

AREA: Walkerville

VIEW: Looking Northeasterly

PHOTO NEGATIVE INDEX: 3A G2 - 3A

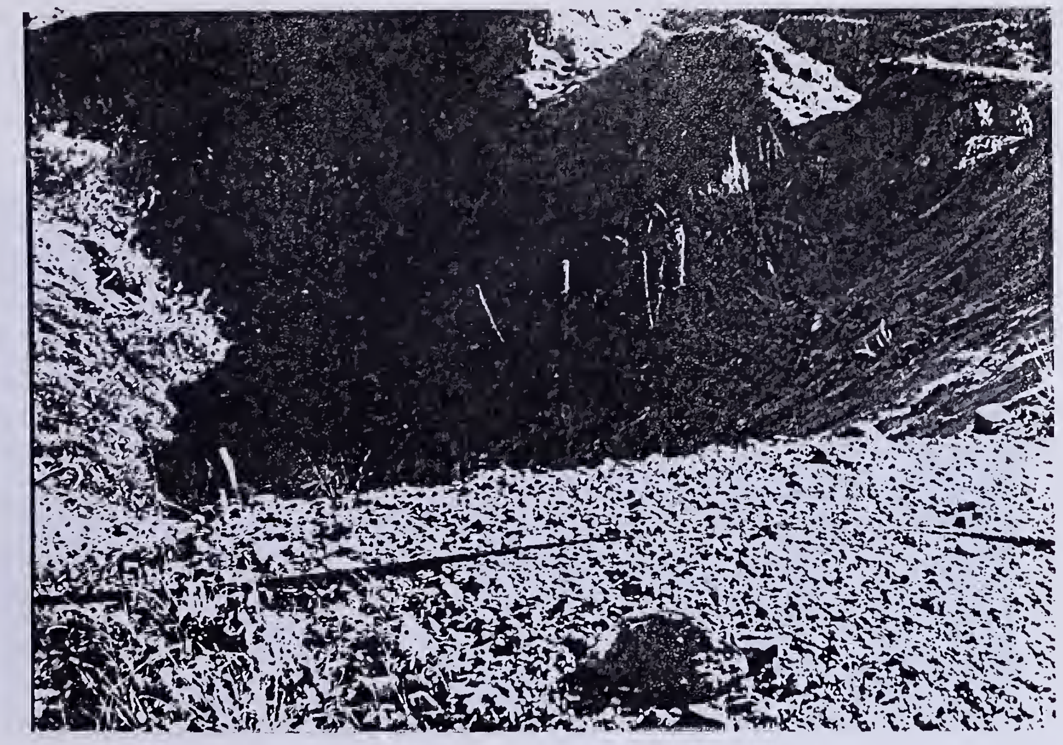
MAP INDEX: U-23-15

MINE: Goldsmith Nonconsolidated

SUBJECT: Shaft subsidence

AERIAL PHOTO INDEX: P5 - 15

PAGE 4 OF 7



SAFETY HAZARD: The recent subsidence shown in the photo was caused by shaft failure. Further caving is a likely possibility. The area is open to the public and, with further caving, would be extremely dangerous. The shaft depth is unknown but given the size of the waste dump, it is probably several hundred feet deep.

HEALTH HAZARD: Barren spoil piles causing dusting problems. No mine water drainage.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: ~~2.5~~ 3

MISCELLANEOUS COMMENTS:

AREA: Walkerville

VIEW: Looking Southeasterly

PHOTO NEGATIVE INDEX: G2 - 4A

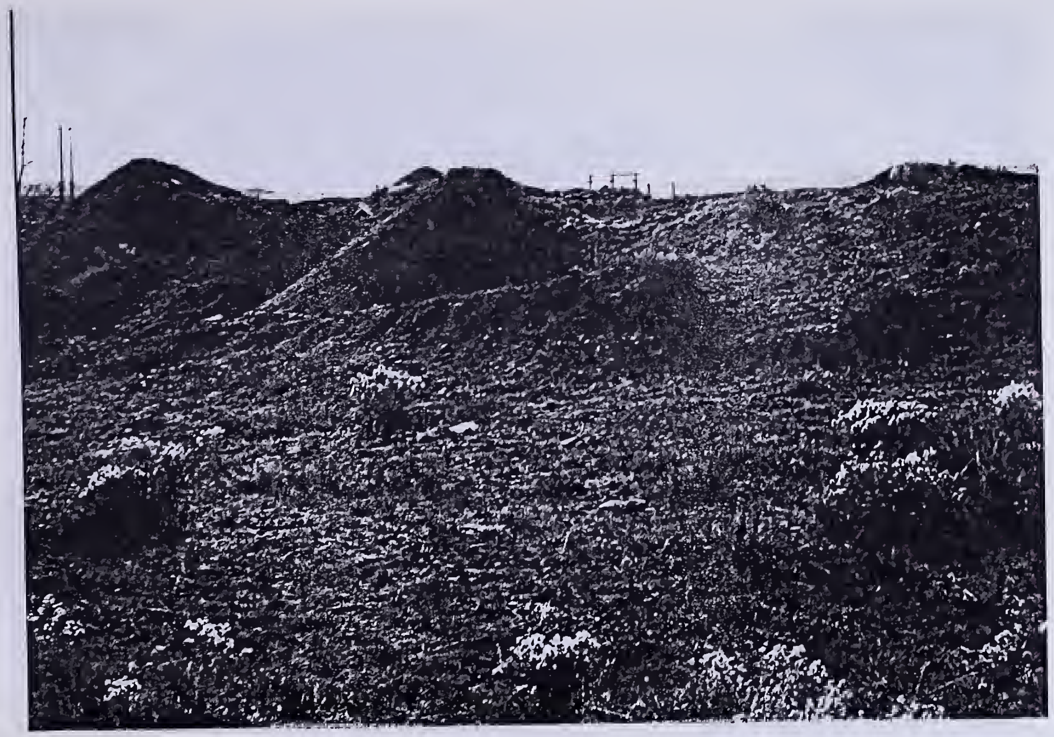
MAP INDEX: U-23-16

MINE: Goldsmith Nonconsolidated

SUBJECT: Dump for shaft

AERIAL PHOTO INDEX: P5 - 16

PAGE 5 OF 7



SAFETY HAZARD: Steep-walled dump

HEALTH HAZARD: Barren spoil piles subject to wind erosion. Note dozer cuts on top of the dump.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 1

MISCELLANEOUS COMMENTS:

AREA: Walkerville

VIEW: Looking Westerly

PHOTO NEGATIVE INDEX: G2 - 5A

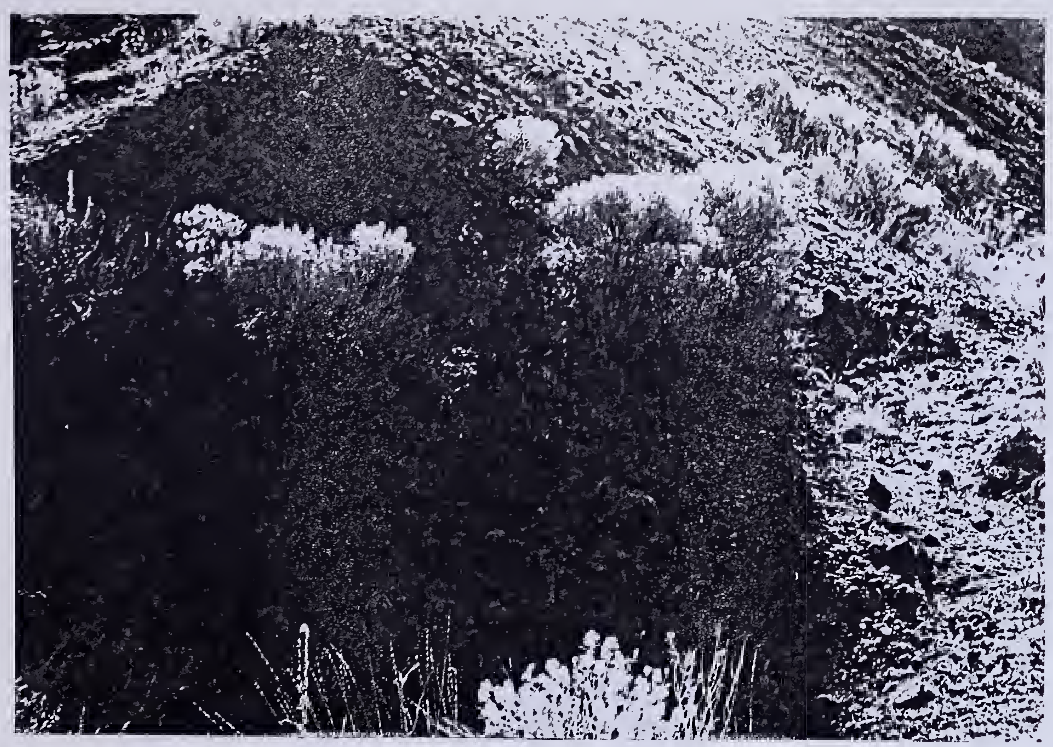
MAP INDEX: U-23-17

MINE: Goldsmith (small shaft)

SUBJECT: Subsided shaft collar

AERIAL PHOTO INDEX: P5 - 17

PAGE 6 OF 7



SAFETY HAZARD: Small shaft caved leaving surface depression

HEALTH HAZARD: Barren spoil pile

HEALTH HAZARD FACTOR: 1

SAFETY HAZARD FACTOR: 1

MISCELLANEOUS COMMENTS:

AREA: Walkerville

VIEW: Looking Southwesterly

PHOTO NEGATIVE INDEX: G2 - 6A

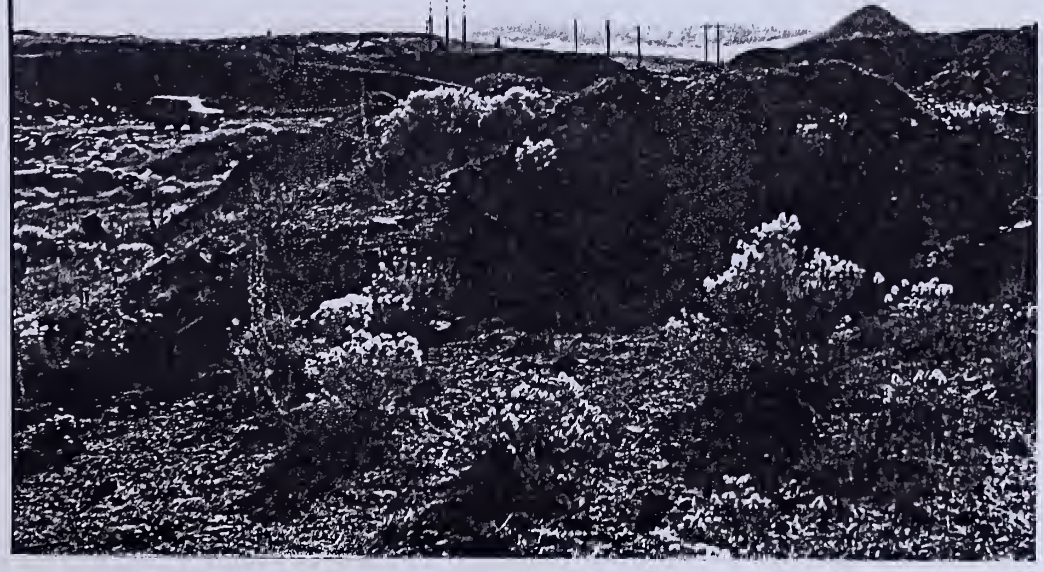
MAP INDEX: U-23-18

MINE: Goldsmith (small shaft)

SUBJECT: Waste dumps for shaft

AERIAL PHOTO INDEX: P5 - 18

PAGE 7 OF 7



SAFETY HAZARD: None

HEALTH HAZARD: Barren spoil pile subject to wind erosion. Small dumps.

HEALTH HAZARD FACTOR: 1

SAFETY HAZARD FACTOR: 1

MISCELLANEOUS COMMENTS:

MISCELLANEOUS AREAS

Numerous units not included in the other areas are separately classified. The are the, Emma, Mary Louise, Travona, Ophir, Star West, Bonanza, Britania, Tzarena, Tecumseh, Anselmo Air Shaft, Anselmo Sand Pass, Henry, and Ardsley Butte.

Of this group of mining units the Travona and Emma are considered to be the most hazardous. The Emma mine shaft has been closed for many years with a wooden bulkhead a short distance below the surface and covered with waste rock. The Travona has a wooden bulkhead on surface only. Both shafts present a serious hazard because of their location in heavily populated areas of Butte.

The Ophir, Mary Louise, and Bonanza present the next most hazardous units in this group. All three shafts are susceptible to caving from bulkhead failure. All three are in heavy populated locations with the Mary Louise and Bonanza being adjacent to High Schools.

The third most hazardous group is the Britania, Anselmo Air Shaft, and the Ardsley Butte. Although of a less hazardous condition they are considered to be unsafe enough to warrant attention.

The remaining four units examined are not considered of such a safety hazard as to need specific attention.

BUTTE AML PROJECT

AREA: Miscellaneous

VIEW: Looking Northwesterly

PHOTO NEGATIVE INDEX: G12-19a

MAP INDEX: A-19-133

MINE: Ardsley Butte

SUBJECT: Shaft

AERIAL PHOTO INDEX: P7-133

PAGE 1 OF 3

SAFETY HAZARD: The Ardsley Butte shaft is 365 feet deep and is located adjacent to residences in Williamsburg south of the metropolitan Butte. The shaft caved and subsided to a depth of 12 to 15 feet and will continue to subside with the possibility of complete failure with an opening to its entire depth.

HEALTH HAZARD: N/A

HEALTH HAZARD FACTOR:

SAFETY HAZARD FACTOR: 4

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Miscellaneous

VIEW: Looking Northerly

PHOTO NEGATIVE INDEX: G12-22a

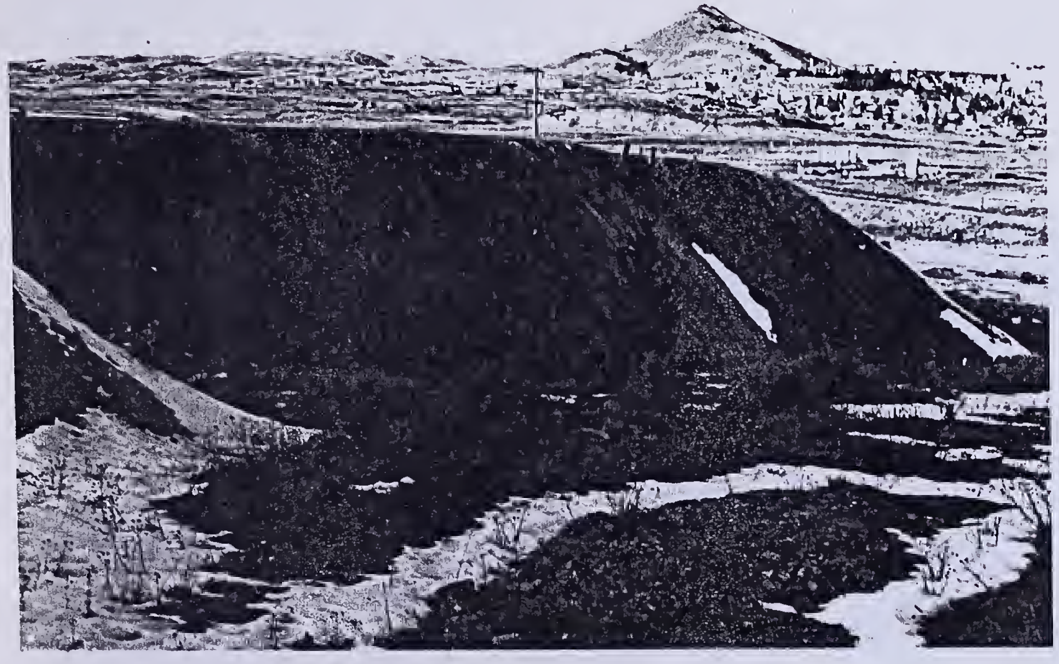
MAP INDEX: A-19-134

MINE: Ardsley Butte

SUBJECT: Waste Dump

AERIAL PHOTO INDEX: P7-134

PAGE 2 OF 3



HEALTH HAZARD: The surface of the waste dump is crusted from oxidation and does not present a dust problem.

SAFETY HAZARD: See page 1

HEALTH HAZARD FACTOR: 1

SAFETY HAZARD FACTOR:

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Miscellaneous

VIEW: Looking Westerly

PHOTO NEGATIVE INDEX: G17-5a

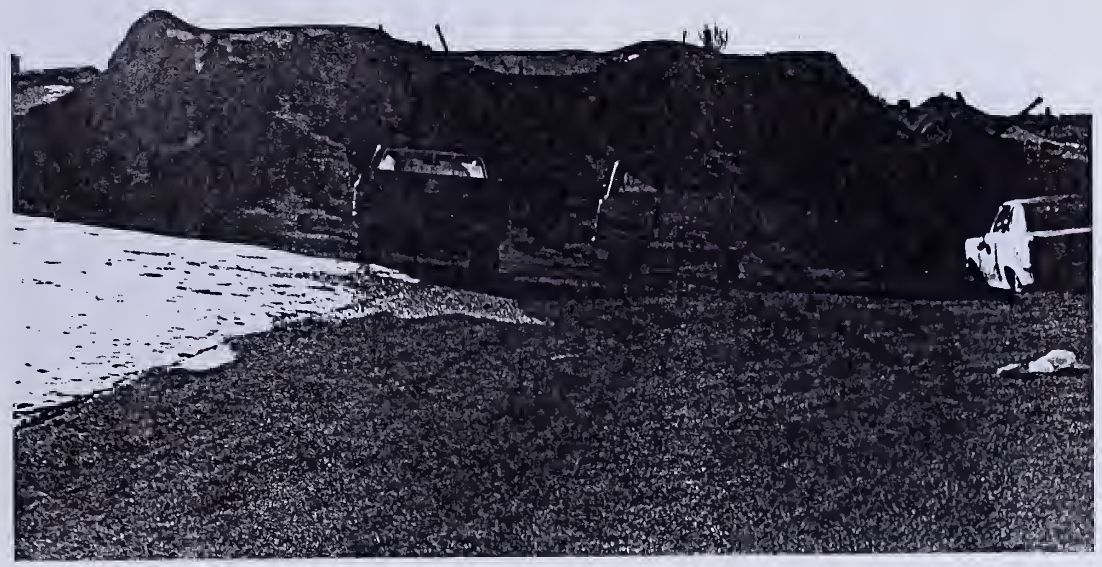
MAP INDEX: A-19-135

MINE: Ardsley Butte

SUBJECT: Butte Ardsley Exhaust Shaft & Dump

AERIAL PHOTO INDEX: P7-135

PAGE 3 OF 3



SAFETY HAZARD: The shaft is probably covered on surface with lagging and buried in waste rock. The shaft cover will fail eventually.

HEALTH HAZARD: The waste dump adjacent to residences is a source of air contamination from dust.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 3

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Miscellaneous

VIEW: Looking Northwesterly

PHOTO NEGATIVE INDEX: G11-20

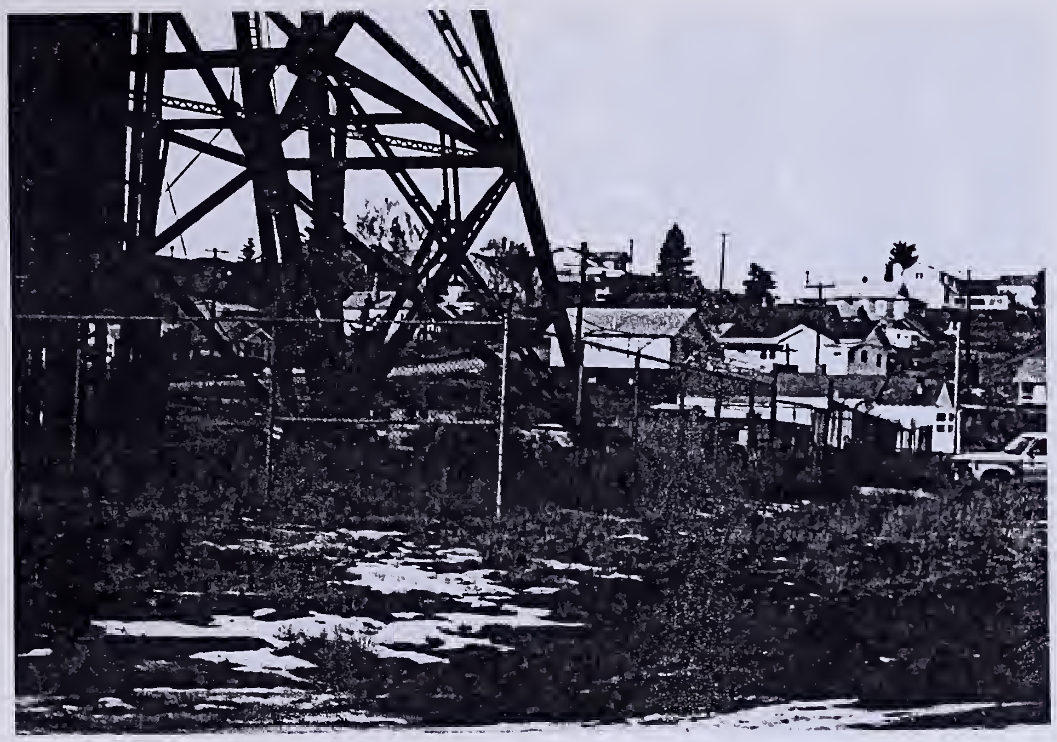
MAP INDEX: E-23-150

MINE: Travona

SUBJECT: Shaft & Headframe

AERIAL PHOTO INDEX: P7-150

PAGE 1 OF 3



SAFETY HAZARD: The 1500 foot deep shaft is covered with a wooden bulkhead on surface with the man cages resting on the bulkhead on two of the compartments. The manway compartment is covered with double 3-inch boards and is vulnerable to entrance. The shaft area is fenced but there is evidence of children at play around the shaft collar.

HEALTH HAZARD: N/A

HEALTH HAZARD FACTOR:

SAFETY HAZARD FACTOR: 5

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Miscellaneous

VIEW: Looking Northerly

PHOTO NEGATIVE INDEX: G11-21

MAP INDEX: E-23-151

MINE: Travona

SUBJECT: Shaft

AERIAL PHOTO INDEX: P7-151

PAGE 2 OF 3

SAFETY HAZARD: See page 1

HEALTH HAZARD: N/A

HEALTH HAZARD FACTOR:

SAFETY HAZARD FACTOR: 5

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Miscellaneous

VIEW: Looking Westerly

PHOTO NEGATIVE INDEX: G11-19

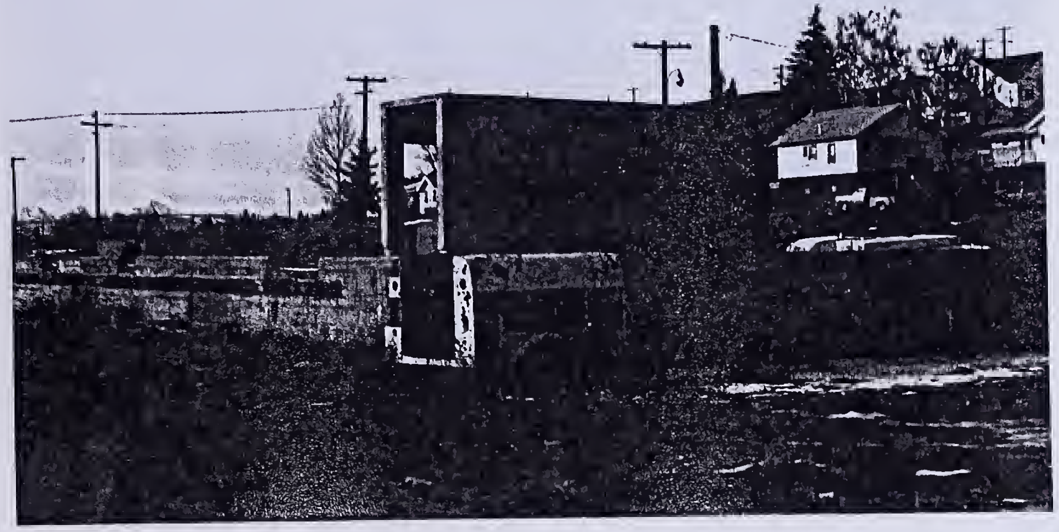
MAP INDEX: E-23-152

MINE: Travona

SUBJECT: Old Foundations

AERIAL PHOTO INDEX: P7-152

PAGE 3 OF 3



SAFETY HAZARD: Old foundations outside the fenced area and open to the public show evidence of children at play. Evidences of small fires in the basemets are seen.

HEALTH HAZARD: N/A

HEALTH HAZARD FACTOR:

SAFETY HAZARD FACTOR: 3

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Miscellaneous

VIEW: Looking Southerly

PHOTO NEGATIVE INDEX: G11-24

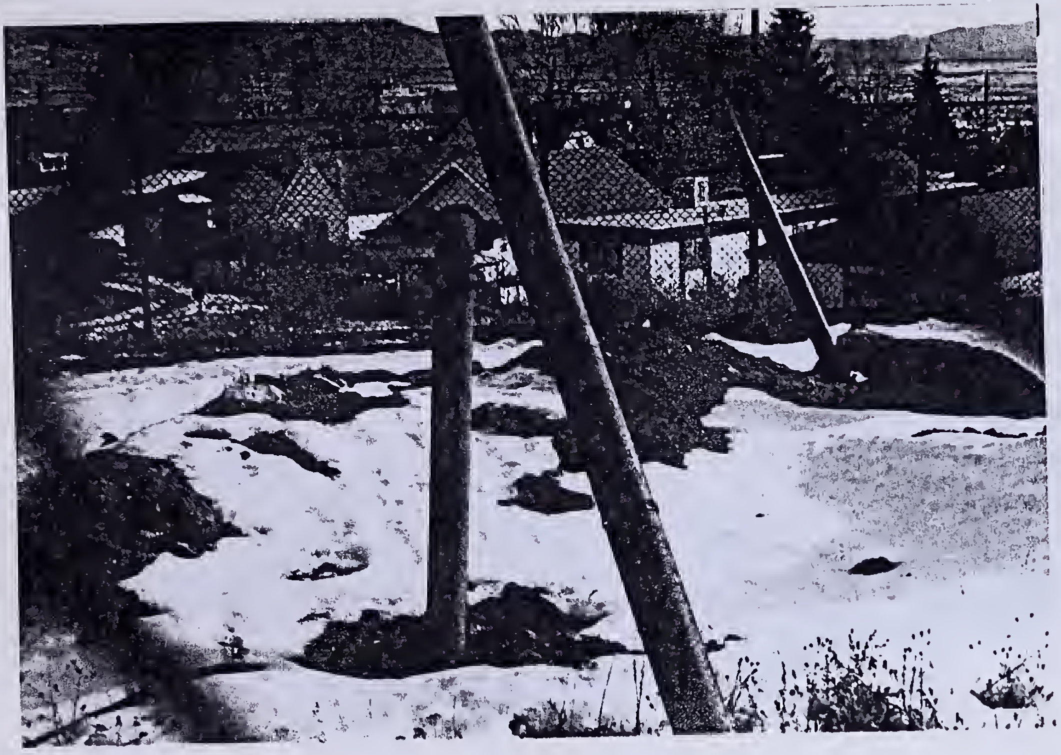
MAP INDEX: I-19-148

MINE: Anselmo Sand Pass

SUBJECT: Shaft Collar

AERIAL PHOTO INDEX: P6-148

PAGE 1 OF 1



SAFETY HAZARD: Sand pass raise covered on surface with wooden bulkhead and rock waste. There is a breather pipe through the bulkhead. The bulkhead will eventually fail but since it is a raise it won't create a great hazard.

HEALTH HAZARD: If the bulkhead fails "bad air" could be released.

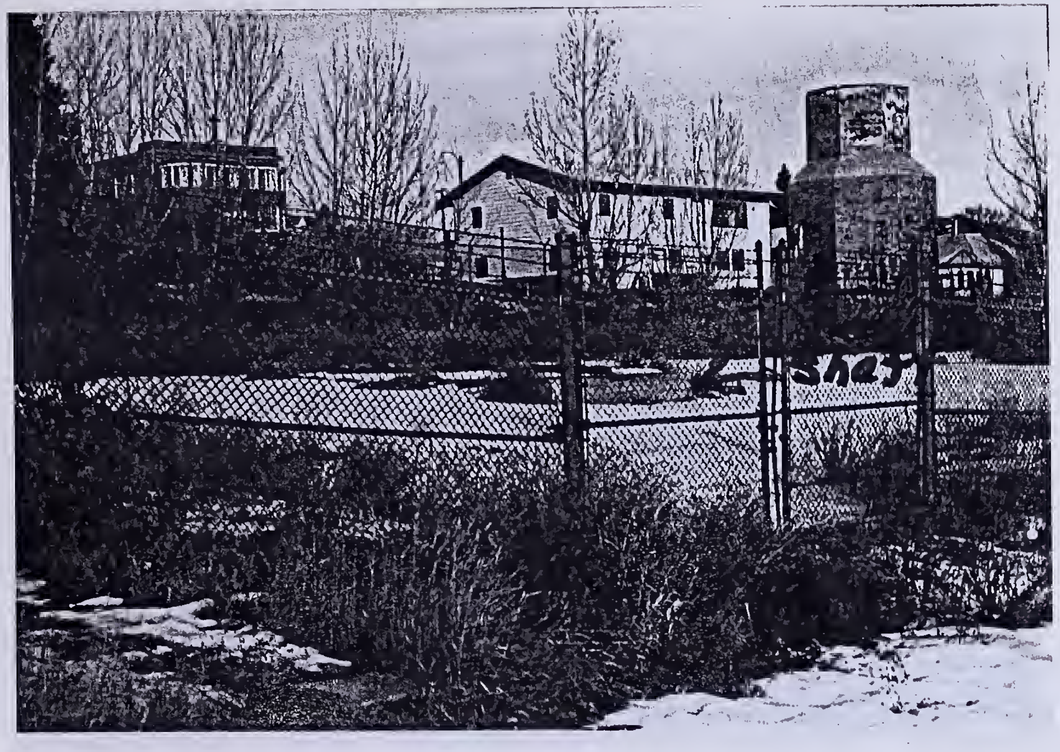
HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 2.5

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Miscellaneous
VIEW: Looking Northeasterly
PHOTO NEGATIVE INDEX: G11-22
MAP INDEX: M-19-149
MINE: Anselmo (Air Shaft)
SUBJECT: Shaft Cover & Fan Tower
AERIAL PHOTO INDEX: P6-149
PAGE 1 OF 1



SAFETY HAZARD: The shaft is covered with a concrete bulkhead on surface. A tunnel 30 or 40 feet below the surface connects the shaft to the concrete tower. Only a locked door guards the entrance to the tower. The area is fenced but shows evidence of entrance to the shaft yard.

HEALTH HAZARD: "Bad air" in the tower can be a serious health hazard.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 3

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Miscellaneous

VIEW: Looking Northerly

PHOTO NEGATIVE INDEX: G11-11

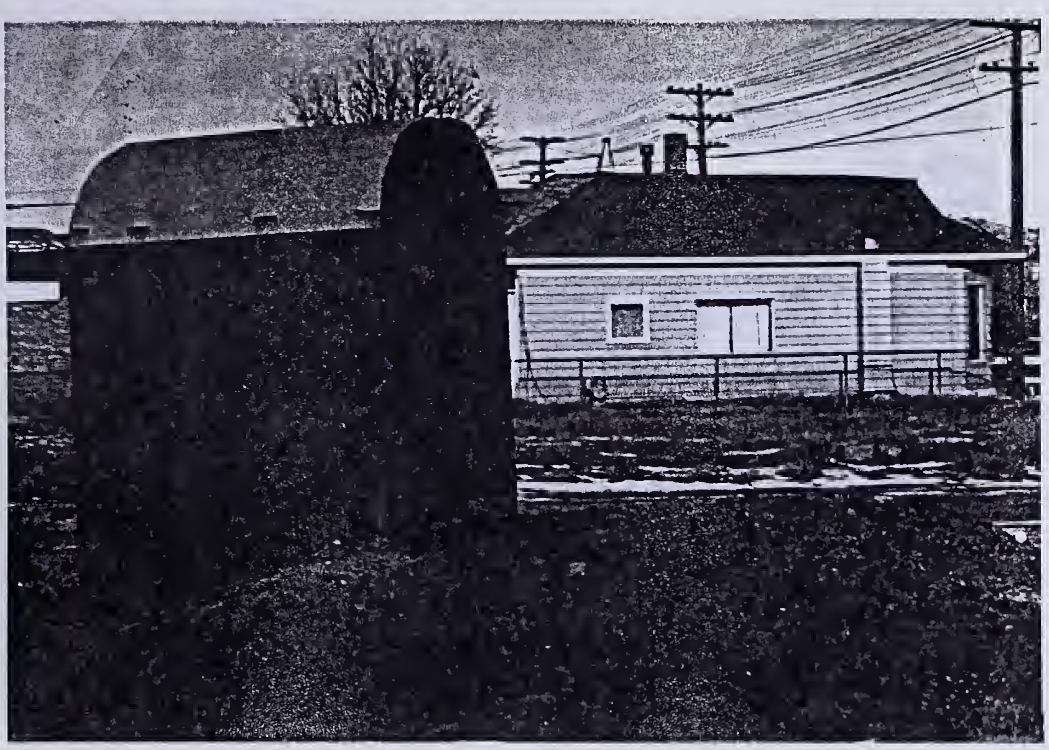
MAP INDEX: E-23-153

MINE: Ophir

SUBJECT: Shaft Cover

AERIAL PHOTO INDEX: P7-153

PAGE 1 OF 4



HEALTH HAZARD: Small caves from rotten timber below the steel building will produce small holes through to the surface allowing "bad air" to escape.

SAFETY HAZARD: The shaft collar is covered by a steel building with no doorway. It is located in a heavily populated area and close to the Webster-Garfield grade school. The shaft timber below the steel building will eventually fail allowing the shaft to be exposed. As the shaft timber rots small holes will appear in the surface around the building - a serious safety hazard.

HEALTH HAZARD FACTOR: 3

SAFETY HAZARD FACTOR: 4

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Miscellaneous

VIEW: Looking Westerly

PHOTO NEGATIVE INDEX: G11-12

MAP INDEX: E-23-154

MINE: Ophir

SUBJECT: Shaft Cover

AERIAL PHOTO INDEX: P7-154

PAGE 2 OF 4

SAFETY HAZARD: Same as page 1

HEALTH HAZARD: Same as page 1

HEALTH HAZARD FACTOR: 3

SAFETY HAZARD FACTOR: 4

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Miscellaneous

VIEW: Looking Southeasterly

PHOTO NEGATIVE INDEX: G11-13

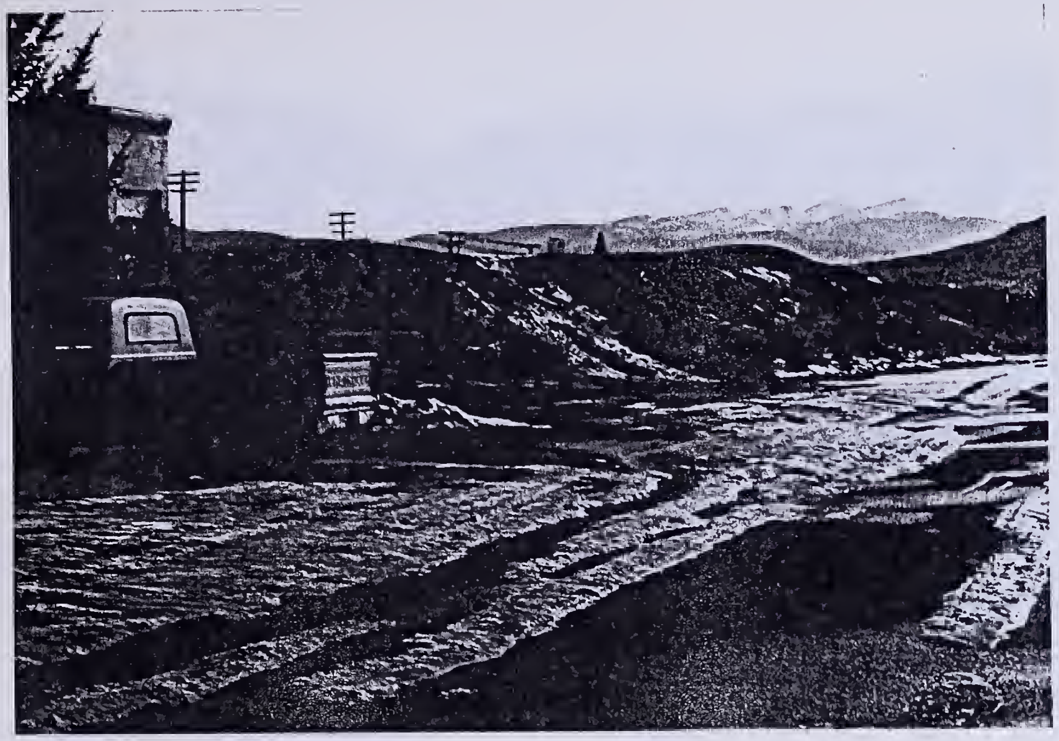
MAP INDEX: E-23-154a

MINE: Ophir

SUBJECT: Waste Dump

AERIAL PHOTO INDEX: P7-154a

PAGE 3 OF 4



SAFETY HAZARD: Same as page 1

HEALTH HAZARD: The waste dump is adjacent to Placer Street and sand from the dump continually erodes to the street causing a dust condition.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR: 4

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Miscellaneous

VIEW: Looking Easterly

PHOTO NEGATIVE INDEX: G11-15

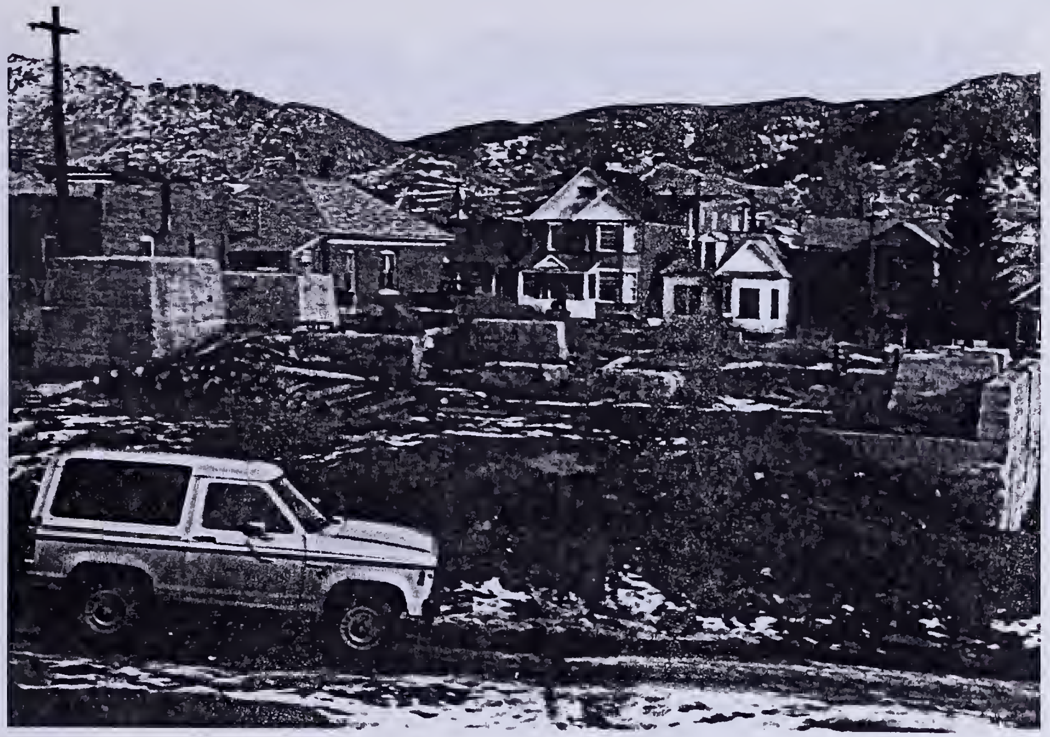
MAP INDEX: E-23-155

MINE: Ophir

SUBJECT: Old Foundations

AERIAL PHOTO INDEX: P7-155

PAGE 4 OF 4



SAFETY HAZARD: Old foundations, not maintained, are a safety hazard to children at play.

HEALTH HAZARD: N/A

HEALTH HAZARD FACTOR:

SAFETY HAZARD FACTOR: 2.5

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Miscellaneous

VIEW: Looking West

PHOTO NEGATIVE INDEX: G11-8

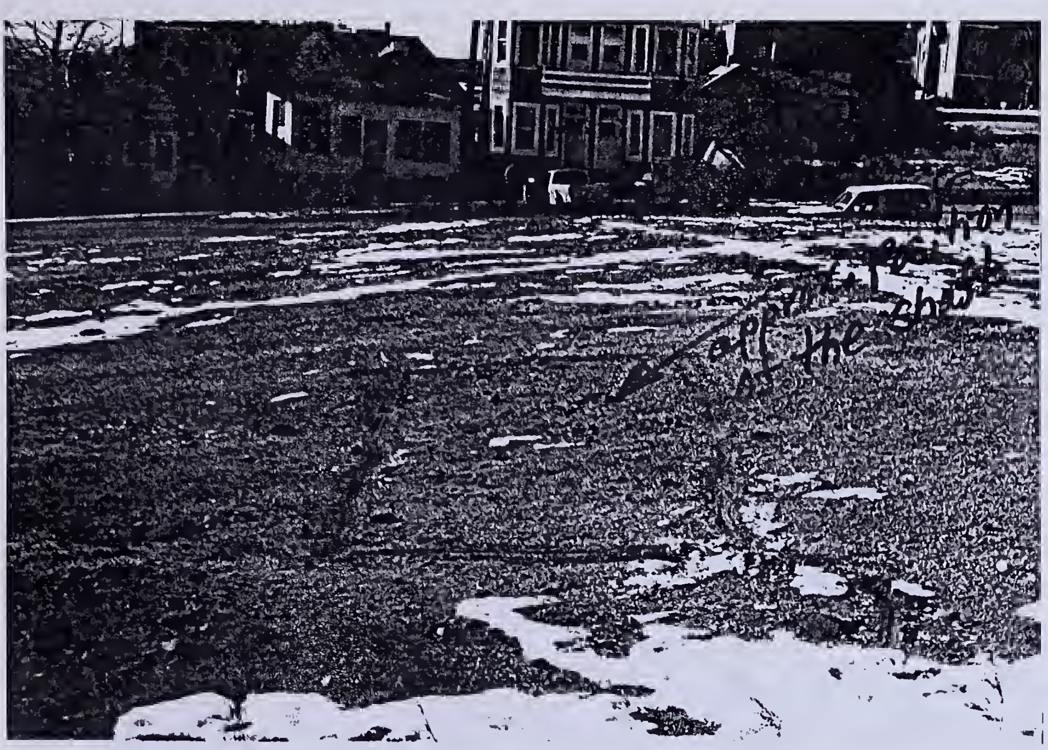
MAP INDEX: I-23-156

MINE: Emma

SUBJECT: Shaft Location

AERIAL PHOTO INDEX: P7-156

PAGE 1 OF 2



SAFETY HAZARD: A wooden bulkhead was placed in the 1700 foot deep shaft between twenty and forty feet below the surface. The shaft was filled with waste rock to the surface. The shaft is full of water to approximately one hundred feet below the surface. The Emma is located in a heavily populated area. The wooden bulkhead will eventually fail and the surface cave in.

HEALTH HAZARD: See page 2

HEALTH HAZARD FACTOR:

SAFETY HAZARD FACTOR: 5

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Miscellaneous

VIEW: Looking Southeasterly

PHOTO NEGATIVE INDEX: G11-10

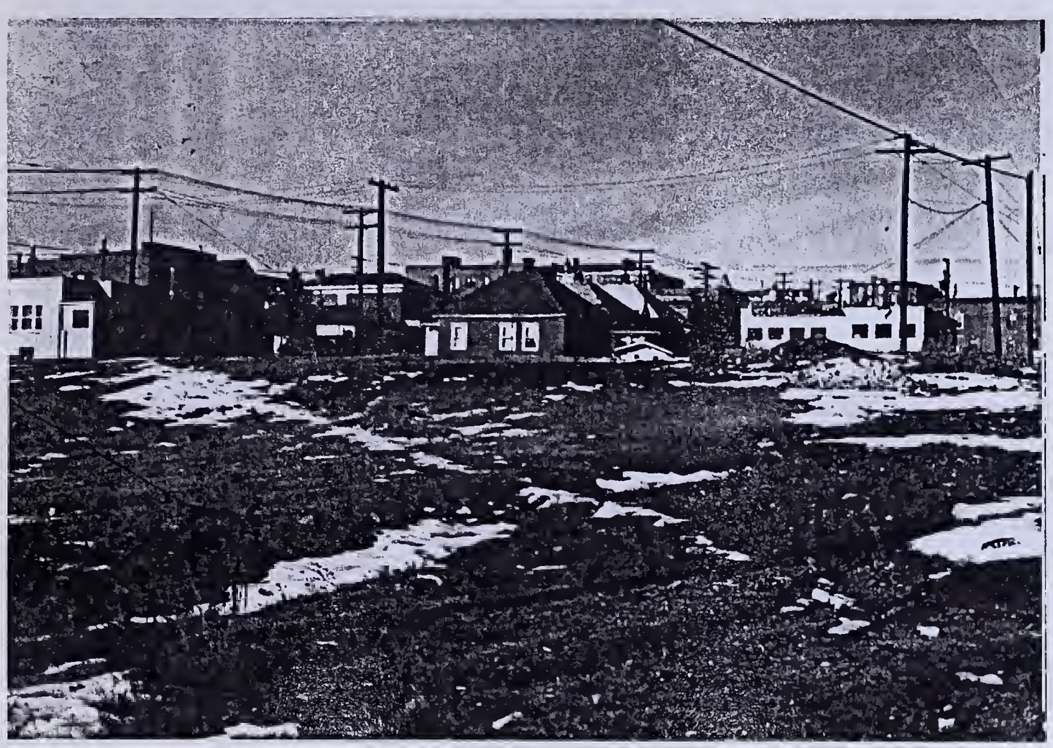
MAP INDEX: I-23-157

MINE: Emma

SUBJECT: Old Yard Area

AERIAL PHOTO INDEX: P7-157

PAGE 2 OF 2



HEALTH HAZARD: The area has been covered with acid waste rock which has created a serious dust condition

SAFETY HAZARD: See page 1

HEALTH HAZARD FACTOR: 3

SAFETY HAZARD FACTOR: 5

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Miscellaneous

VIEW: Looking Northeasterly

PHOTO NEGATIVE INDEX: G17-4a

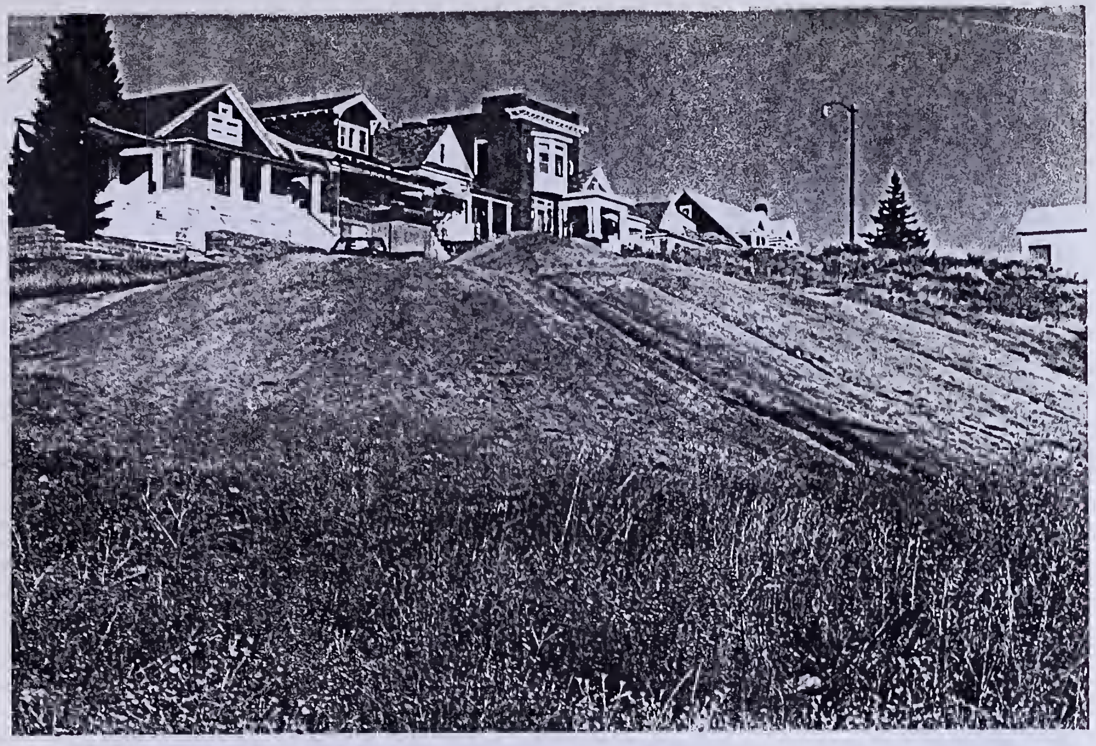
MAP INDEX: I-23-161

MINE: Henry

SUBJECT: Waste Dump

AERIAL PHOTO INDEX: P6-161

PAGE 1 OF 1



HEALTH HAZARD: Dust from the waste dump can be injurious to residents living close by.

SAFETY HAZARD: The dump has been filled in years past. There may be a small amount of subsidence over the shaft area due to compaction. No hazard exists.

HEALTH HAZARD FACTOR: 1

SAFETY HAZARD FACTOR: 0

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Miscellaneous

VIEW: Looking Southwesterly

PHOTO NEGATIVE INDEX: G15-13

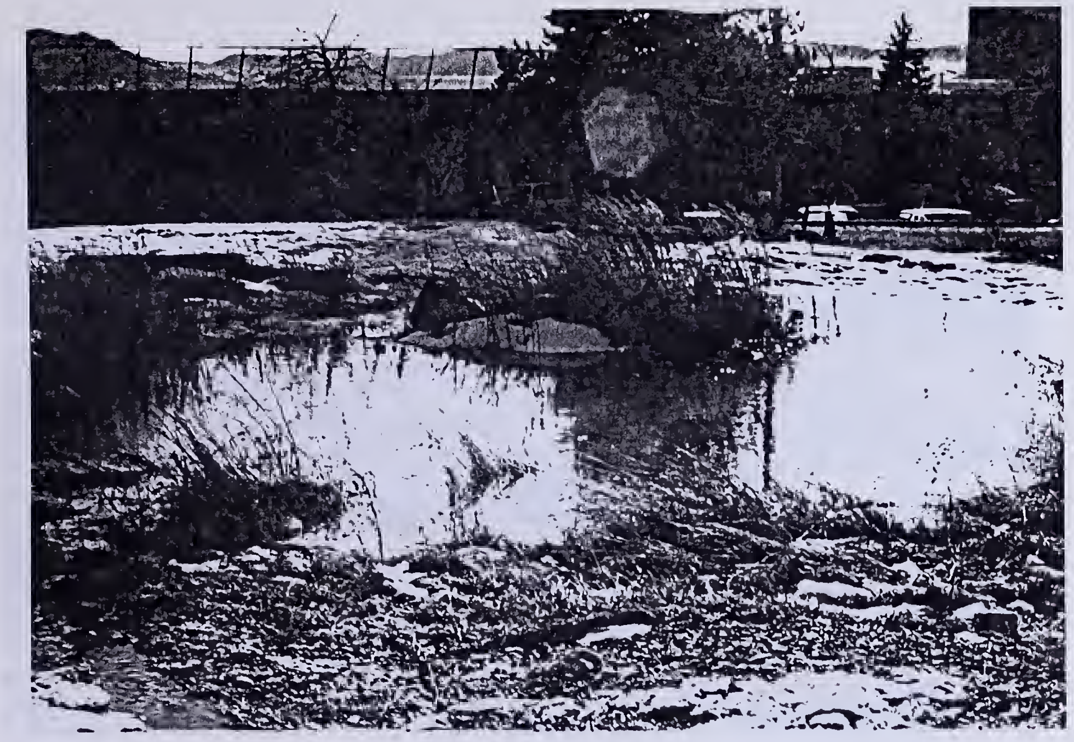
MAP INDEX: I-27-130

MINE: Mary Louise

SUBJECT: Shaft Collar Location

AERIAL PHOTO INDEX: P7 & P6 -130

PAGE 1 OF 1



SAFETY HAZARD: A concrete bulkhead 3 feet thick , 70 feet below the surface was placed in the Mary Louise shaft about twenty years ago. It is not known whether there were hitches cut into the walls or not. Waste rock was filled from the bulkhead to surface. The depth of the shaft is approximately 500 feet deep.

The shaft is located on surface in a depression that is filled with water as shown in the photo. The bulkhead has evidently begun to fail causing the depression.

The shaft is located in a park adjacent to the Butte High School facilities

HEALTH HAZARD: N/A

HEALTH HAZARD FACTOR:

SAFETY HAZARD FACTOR: 4

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Miscellaneous

VIEW: Looking Northerly

PHOTO NEGATIVE INDEX: G12-7a

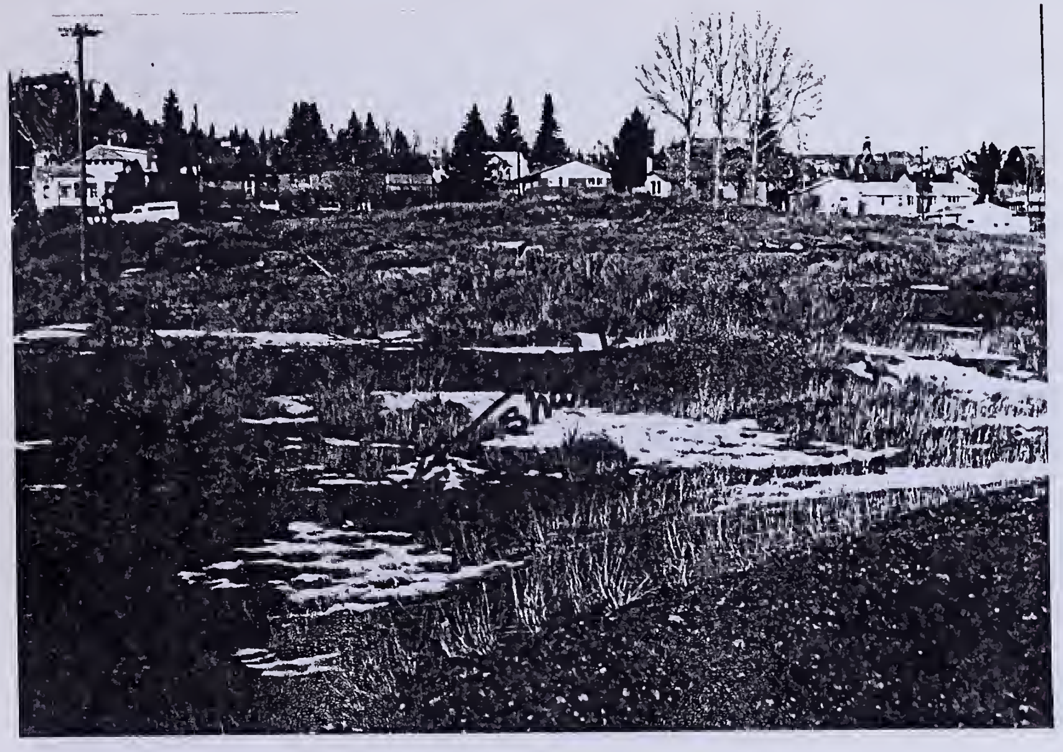
MAP INDEX: E-19-143

MINE: Britania

SUBJECT: Shaft Location

AERIAL PHOTO INDEX: P7-143

PAGE 1 OF 2



SAFETY HAZARD: There is no evidence of a borrow area indicating that the 400 foot shaft has been filled. If not, the shaft is a particular safety hazard because it is close to residences and the West Junior High School.

HEALTH HAZARD:

HEALTH HAZARD FACTOR:

SAFETY HAZARD FACTOR: 3

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Miscellaneous

VIEW: Looking Northeasterly

PHOTO NEGATIVE INDEX: G12-5a

MAP INDEX: E-19-144

MINE: Britania

SUBJECT: Waste Dump

AERIAL PHOTO INDEX: P7-144

PAGE 2 OF 2

SAFETY HAZARD: See page 1

HEALTH HAZARD: Dust from the waste dump is carried by the prevailing northwest winds to the populated area a short distance to the north causing a health hazard.

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR:

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Miscellaneous

VIEW: Looking Northerly

PHOTO NEGATIVE INDEX: G12-6a

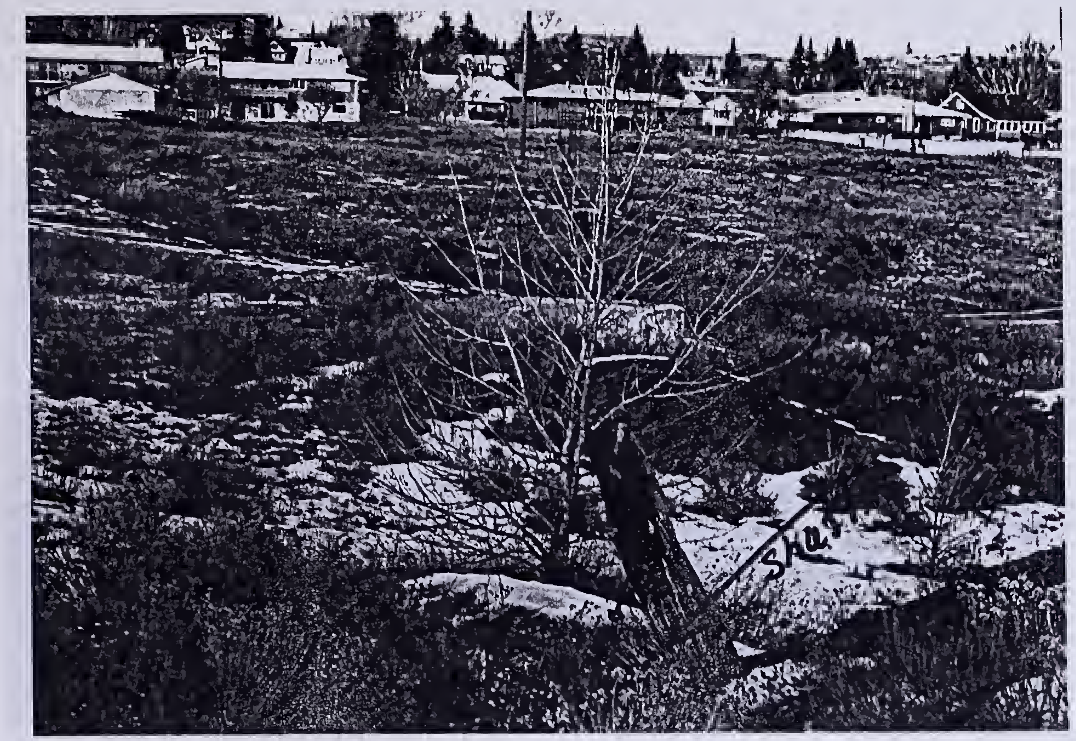
MAP INDEX: E-19-140

MINE: Tzarena

SUBJECT: Shaft Collar

AERIAL PHOTO INDEX: P7-140

PAGE 1 OF 1



SAFETY HAZARD: The shaft is 150 feet deep and was filled several years ago. No hazard exists at this shaft.

HEALTH HAZARD: N/A

HEALTH HAZARD FACTOR:

SAFETY HAZARD FACTOR: 0

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Miscellaneous

VIEW: Looking Northeasterly

PHOTO NEGATIVE INDEX: G12-12a

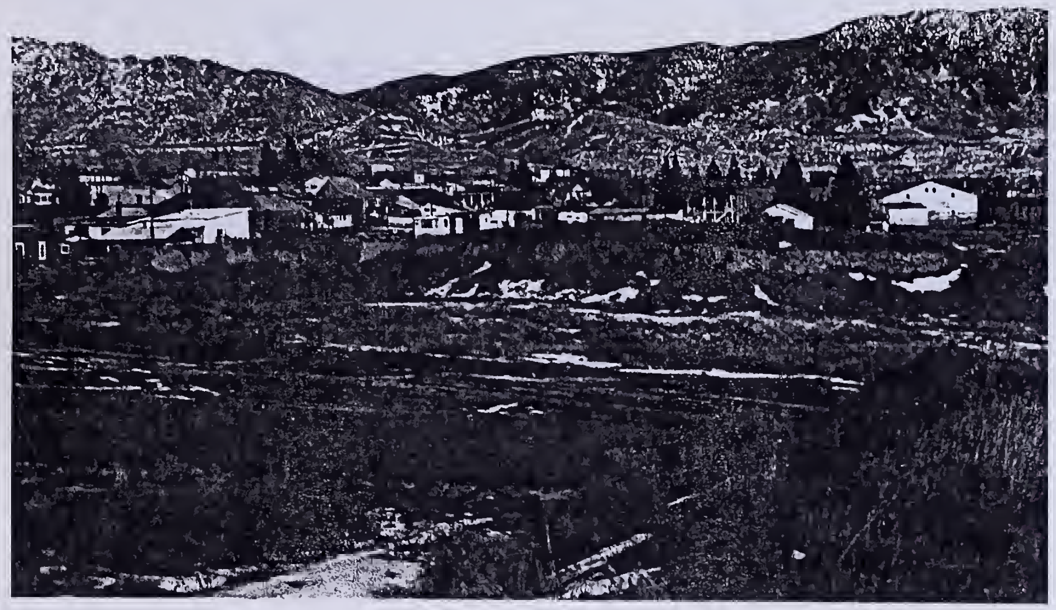
MAP INDEX: E-23-137

MINE: Emma Waste Dump

SUBJECT: Waste Dump

AERIAL PHOTO INDEX: P7-137

PAGE 1 OF 1



HEALTH HAZARD: The waste rock from the Emma mine was hauled to this location. The waste rock pile is a source of dust for the residences close by.

SAFETY HAZARD: N/A

HEALTH HAZARD FACTOR: 2

SAFETY HAZARD FACTOR:

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Miscellaneous

VIEW: Looking Easterly

PHOTO NEGATIVE INDEX: G12-15a

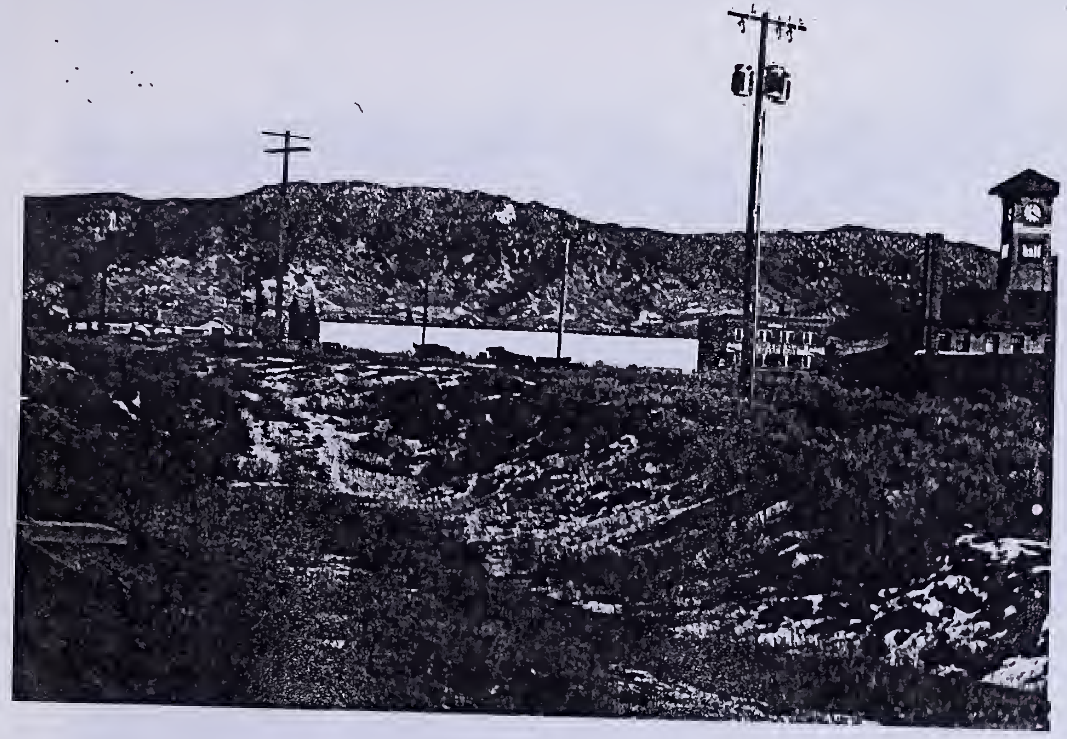
MAP INDEX: E-23-136

MINE: Tecumseh

SUBJECT: Waste Dump

AERIAL PHOTO INDEX: P7-136

PAGE 1 OF 1



SAFETY HAZARD: The collar of the 200 foot shaft was covered with a wooden bulkhead about 20 years ago. Later the wooden cover was buried with waste rock. The shaft cover will enventually fail.

HEALTH HAZARD: N/A

HEALTH HAZARD FACTOR:

SAFETY HAZARD FACTOR: 3

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Miscellaneous

VIEW: Looking Northerly

PHOTO NEGATIVE INDEX: G12-11a

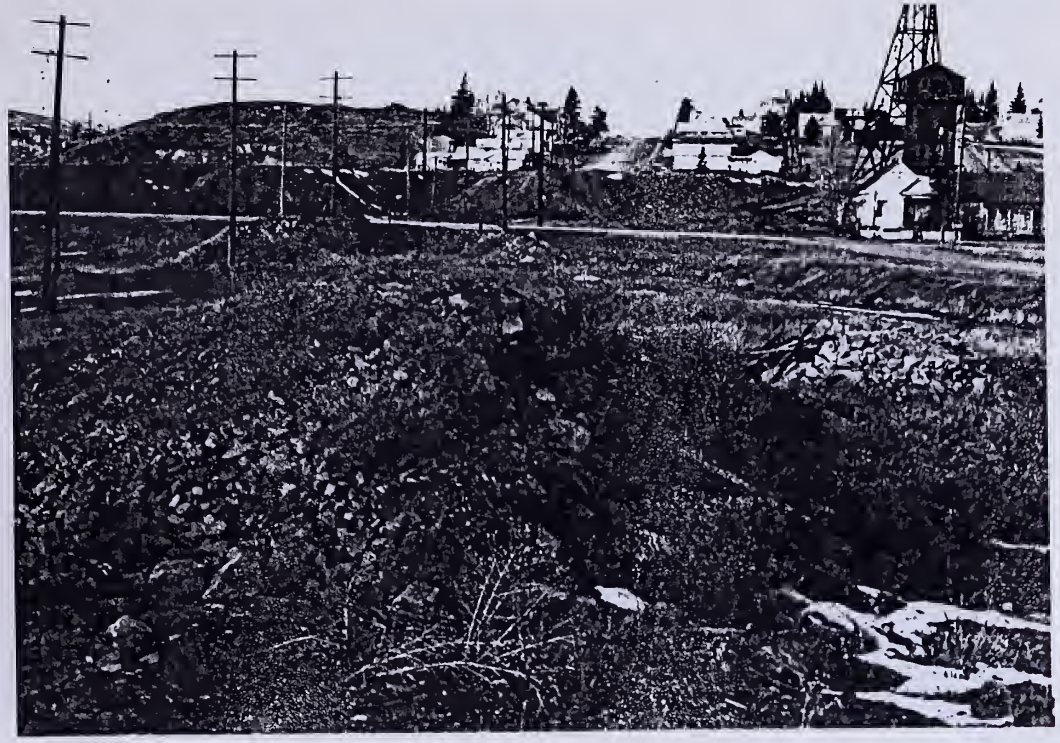
MAP INDEX: E-23-131

MINE: Star West

SUBJECT: Shaft

AERIAL PHOTO INDEX: P7-131

PAGE 1 OF 2



SAFETY HAZARD: The 300 foot deep shaft was filled several years ago and presents no hazard.

HEALTH HAZARD: See page 2

HEALTH HAZARD FACTOR:

SAFETY HAZARD FACTOR: 0

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Miscellaneous

VIEW: Looking Northwesterly

PHOTO NEGATIVE INDEX: G12-14a

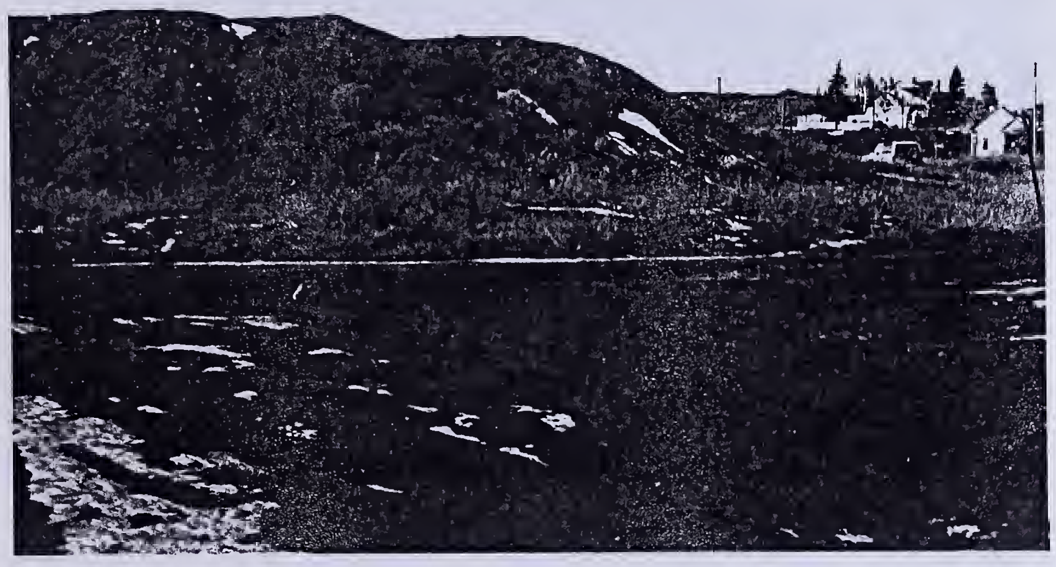
MAP INDEX: E-23-132

MINE: Star West

SUBJECT: Waste Dump

AERIAL PHOTO INDEX: P7-132

PAGE 2 OF 2



HEALTH HAZARD: The waste dump is adjacent to residences on the south. Dust from the dump is a health hazard.

SAFETY HAZARD: See page 1

HEALTH HAZARD FACTOR: 1

SAFETY HAZARD FACTOR:

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Miscellaneous

VIEW: Looking Northwesterly

PHOTO NEGATIVE INDEX: G12-8a

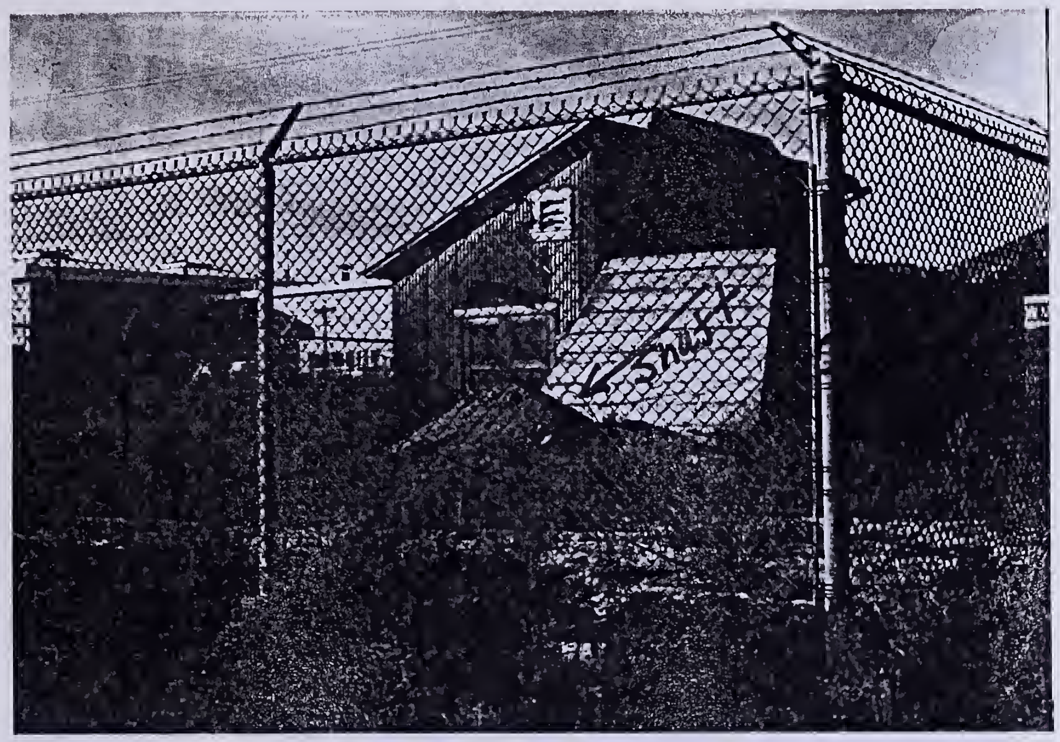
MAP INDEX: E-23-138

MINE: Bonanza

SUBJECT: Bonanza Air Shaft

AERIAL PHOTO INDEX: P7-138

PAGE 1 OF 2



SAFETY HAZARD: The Bonanza shaft is 1000 feet deep and is adjacent to West Junior High School. A bulkhead is located on the shaft a few feet below the surface and is composed of 3-inch boards covered by unreenforced concrete. Waste rock covers the bulkhead as shown in the photo. The wooden bulkhead support will eventually rot and fail pulling the surface down.

HEALTH HAZARD: N/A

HEALTH HAZARD FACTOR:

SAFETY HAZARD FACTOR: 4

MISCELLANEOUS COMMENTS:

BUTTE AML PROJECT

AREA: Miscellaneous

VIEW: Looking Southerly

PHOTO NEGATIVE INDEX: G12-9a

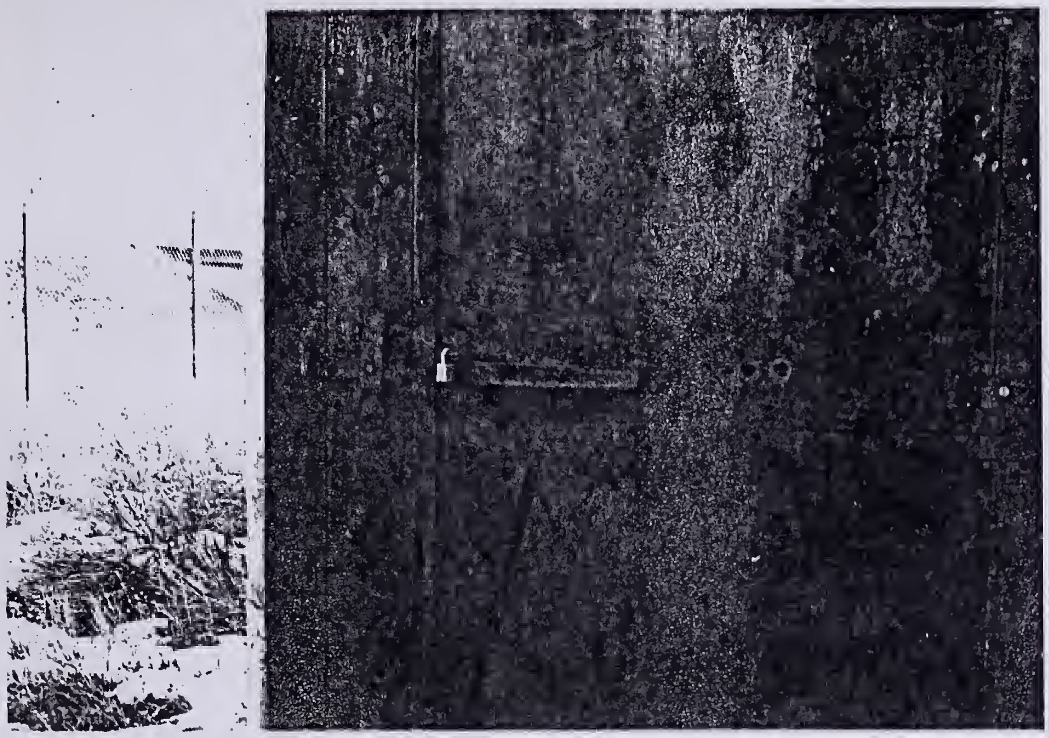
MAP INDEX: E-23-139

MINE: Bonanza

SUBJECT: Fan Housing

AERIAL PHOTO INDEX: P7-139

PAGE 2 OF 2



SAFETY HAZARD: The Fan housing is protected only with a padlock. The fence is easily scaled and the lock could be broken by vandals who would then enter the fan house. The close proximity to the West Junior High School makes this shaft and shaft house particularly vulneable to entrance.

HEALTH HAZARD: N/A

HEALTH HAZARD FACTOR:

SAFETY HAZARD FACTOR: 2.5

MISCELLANEOUS COMMENTS:

Appendix B

PIPER & ASSOCIATES, INC.
Mining Industry Consultants
2940 Edwards St., Butte, Montana 59701
(406) 494-5369 or (406) 723-8905

SURFACE SUBSIDENCE - Metropolitan Butte
Emma - Travona Area

The Emma and Travona mines were operated together from the early 1940's to in or about 1959, at which time all mining was suspended and the mines allowed to fill with water. Previous to that time the Emma was operated on a small scale beginning about 1934 or 1935 to the 1940's, when the size of the mining program was increased extensively. During this period of extensive mining in both the Emma and the Travona considerable subsidence took place on the surface, encompassing an area, roughly triangular in shape, the northwesterly side of which begins at a point approximately 400 feet south of Platinum Street and 200 feet west of Crystal Street and extending northeasterly to about the corner of Mercury and Arizona Streets. The western leg of the triangle extends from the corner of Mercury and Arizona to about the corner of Iron and Colorado Streets, thence back to the point of beginning.

Both the Emma and Travona are relatively shallow mines, 1700 and 1500 feet deep respectively, with the ore horizons from about the 1200 foot level to surface. The ore was stoped out to the 300 foot level with pillars left from there to surface. Nearly all of the mined-out openings were filled with granite sand mined from the Silver Bow "Flat" area. The sand was washed into the mine openings with water to enhance consolidation of the particles. Although the filling operation was well done, considerable surface subsidence occurred with further compaction of the sand fill. The two mines are filled with water to about 200 feet below surface which stablizes the ground support. Subsidence, although reduced, will continue almost indefinitely

as the sand grains adjust to consolidation and the unfilled areas relax and cave.

A lateral compression zone caused by sudsidence from mining in the 1940's and 1950's along the vein in the Emma and Travona mines paralleled the north boundary of the subsidence area and extended southward about 300 to 500 feet from the northerly boundary. The portion of the subsidence area south from the compression zone was under tension as well as subsidence, but moved in large blocks or segments 300 to 400 feet in length, and parallel to the mining. The tension movement at the contacts of the blocks or segments caused considerable damage to property, pipe, and sewer lines. Dressor-type couplings were installed on both water and gas mains to compensate for the elongation. Sewer lines were severed by both the tension and subsidence. Failures also appeared in the compression zone where pipe lines and sewer lines buckled and burst.

Subsidence in the Emma-Travona area can be compared to a set of books on a shelf. When the end book is removed it will cause the remaining books to lean toward the opening. The removed book exemplifies the compression zone, the remaining books the block or segments that moved under tension and subsidence.

When mining ceased in the Emma and Travona mines in 1959, subsidence in the area reduced rapidly and at present only small evidences of continued movement is apparent. Some sewer lines separated and some water lines broke from ground movement, but the rate was greatly reduced compared to the heavy movement experienced during the mining phase.

Present Subsidence - Utility Reports

Records of sewer line breaks, as reported by Bill Mehrens, Head of the Silver Bow Sewer Dept., that have been caused by surface subsidence from mining over the past eight years in the Emma and Travona mines are listed:

Date	Location
Mid-1983	600 Block-So. Main St.
April 4, 1983	900 Block-So. Montana St.
Nov. 15, 1982	600 Block-So. Clark St.
Nov. 29, 1982	600 Block-So. Idaho St.
Aug. 8, 1978	500 Block-So. Montana St.

No breaks occurred in the area during the years 1976, 1977, 1979, 1980, and 1981.

According to Mr. Mehrens the breaks showed some offset (up to 3 inches) but none were of the serious nature similar to those experienced during the Emma-Travona mining phase.

According to Len LeVeaux, Butte Division Engineer and Robert Vivian, Butte Division Foreman of the gas department of the Montana Power Co., there has been only slight movement during the past seven years on some of the Dressor couplings on gas pipe lines in the Emma-Travona area. They also said that the amount of movement was not of such quantity as to indicate any detectable subsidence.

Mr. Michael Patterson of the Butte Water Co. stated there has been some movement during the past seven years in the Emma-Travona area as indicated by pipes that have both telescoped and pulled apart. The movement has been more or less confined to Montana at Platinum and Gold Streets and the 700 block on Maryland Street. He also stated that the movement is at such a slow rate that a break in a water main appeared at each of the locations only once during the seven years and has not repeated itself. He also noted that three breaks on Maryland Street all happened within the last four or five months.

Subsidence Rate - Emma-Travona

Subsidence rate during the past twenty years is not available and almost impossible to estimate. After about 1961 no elevations were measured in the Emma-Travona area at which time the rate had slowed to an almost negligible amount. At this time the decision was made to discontinue any rate of subsidence study.

Presently, only by the results of a series of precise levels over a period of more than a year could any attempt be made to quantify the slow rate of subsidence being experienced in the Emma-Travona area. Even with such information gathered from precise surveys no average rate could be developed for the entire area. During the period of extensive subsidence in the 1940's and 1950's no average rate was developed but rather rates for very small areas surrounding each bench mark.

Subsidence in the Emma-Travona area varied extensively from both the southern extremity of the area to the north boundary and from the west to the east. As pointed out heretofore the movement was confined to blocks or segments and the subsidence of each varied. At the present time with such little subsidence it would be impossible to distinguish between the blocks or segments of movement.

Buffalo Gulch Storm Sewer

An inspection was made in the Buffalo Gulch Storm Sewer on March 15, 1983. The sewer was entered at the corner of Mercury and Colorado Streets and the exit was made at the corner of Iron and Dakota Streets. Many sections of the stone arch and brick arch sewer was replaced with concrete tubes during the period of extensive subsidence in the 1940's and 1950's. The most northerly major replacement section was located at a point about 100 feet south of Mercury Street which was done during this heavy subsidence period. Several other replacement sections exist between Mercury and Aluminum Streets which were also constructed during the era of heavy movement.

Several cracks in the brick arch section between Aluminum and Iron Streets caused by surface tension were noted. A few of the cracks showed signs of movement that had taken place within the past year. Several were reported by Bill Mehrens to have taken place during the past seven years (see photos showing the cracks in the masonry). The estimated aggregate tension movement during the seven years in the section between Aluminum and Iron Streets is about 6 to 8 inches.

Kelley Block-Cave Area

During the late 1940's to about 1960 subsidence appeared on the surface in the east side of Butte, extending from about Ohio Street on the west, eastward to the end of Park and Broadway Streets, now in the Berkeley Pit, and south from the Moonlight and Neversweat Mine area to Mercury Street. The subsidence was not in the magnitude of the Emma-Travona area but did cause some damage to pipe and sewer lines. The subsidence stopped with the cessation of mining by block-cave methods in that particular area. No recent subsidence has been noted.

The area has been almost entirely purchased as a buffer to the Berkeley Pit by the Anaconda Minerals Co. with only less than ten buildings remaining.

Other Subsidence Areas

The subsidence around the periphery of the Alice Pit will continue if the pit walls are not stablized with fill. All rock faces, particularly those that have been shattered by blasting, will spall in an attempt to assume a 38° slope.

Also, the subsidence started during the mining phase, particularly on the north side, as blocks or segments of movement that dropped vertically and leaned toward the pit opening, will continue to move at a much reduced rate compared to the movement during mining. The movement will continue for an extended period of time.

Conclusions

Subsidence in the Emma-Travona area, although very small in comparison to the movement experienced during the mining phase, will continue indefinitely as the fill material continues to consolidate and the unfilled openings cave.

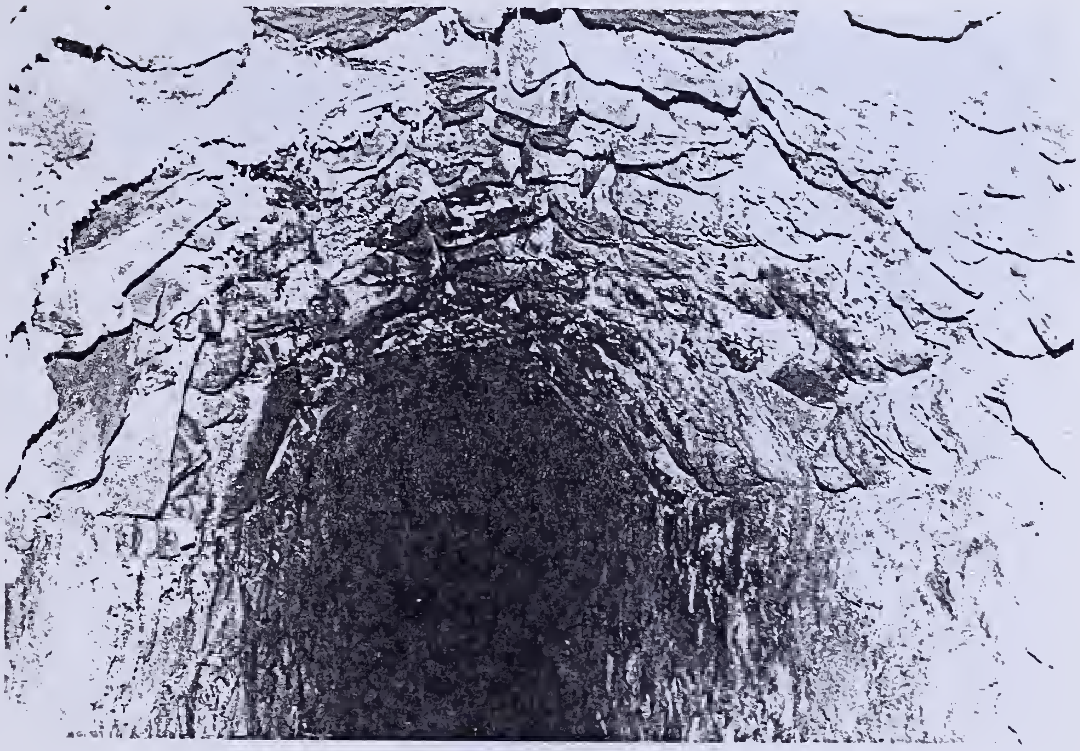
Some subsidence, although not serious, in the east side of Metropolitan Butte can be expected in the future aggravated by the relaxation of the Berkeley Pit walls.

Some subsidence will continue around the periphery of the Alice Pit. The steep walls will relax and cause tension move-up to a 100 feet or more from the pit rim.

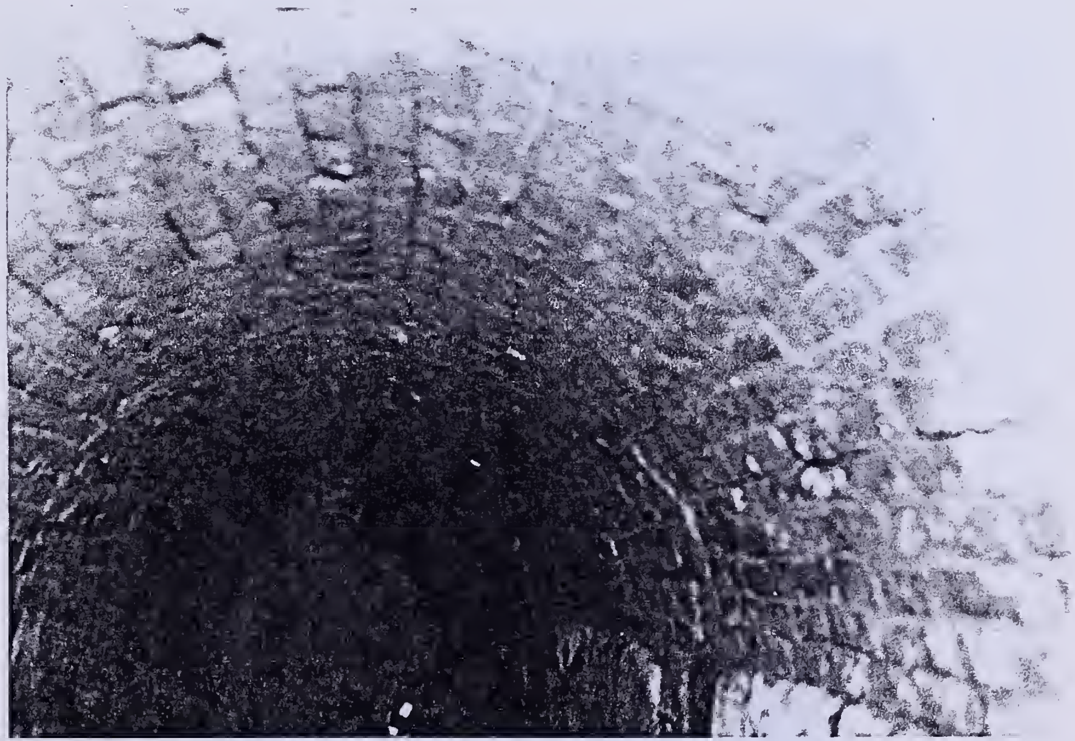
The northwest wall of the Syndicate Pit will continue to spall and subside. Although not serious, subsidence will appear 100 or more feet back of the pit rim.

There is no practical remedy for the small amount of subsidence that will continue in both the Emma-Travona and East Side areas. The amount of movement will lessen over the years but some movement will continually be experienced.

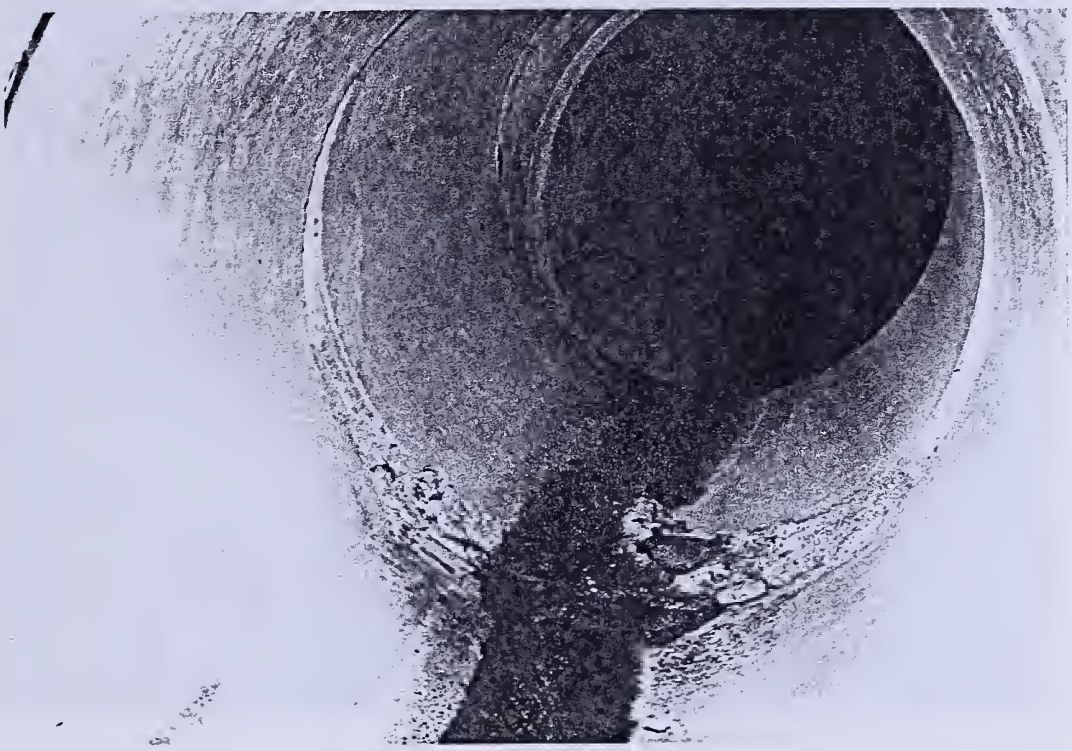
The subsidence that is expected around the rims of both the Alice and Syndicate pits will lessen with the addition of fill to stabilize the slopes.



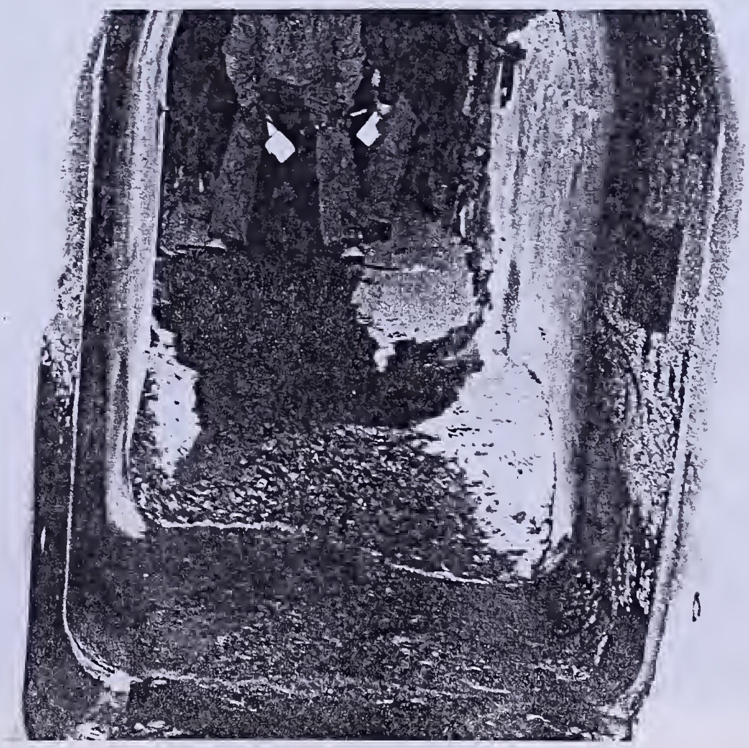
Typical Rubble Arch
Negative Index #3



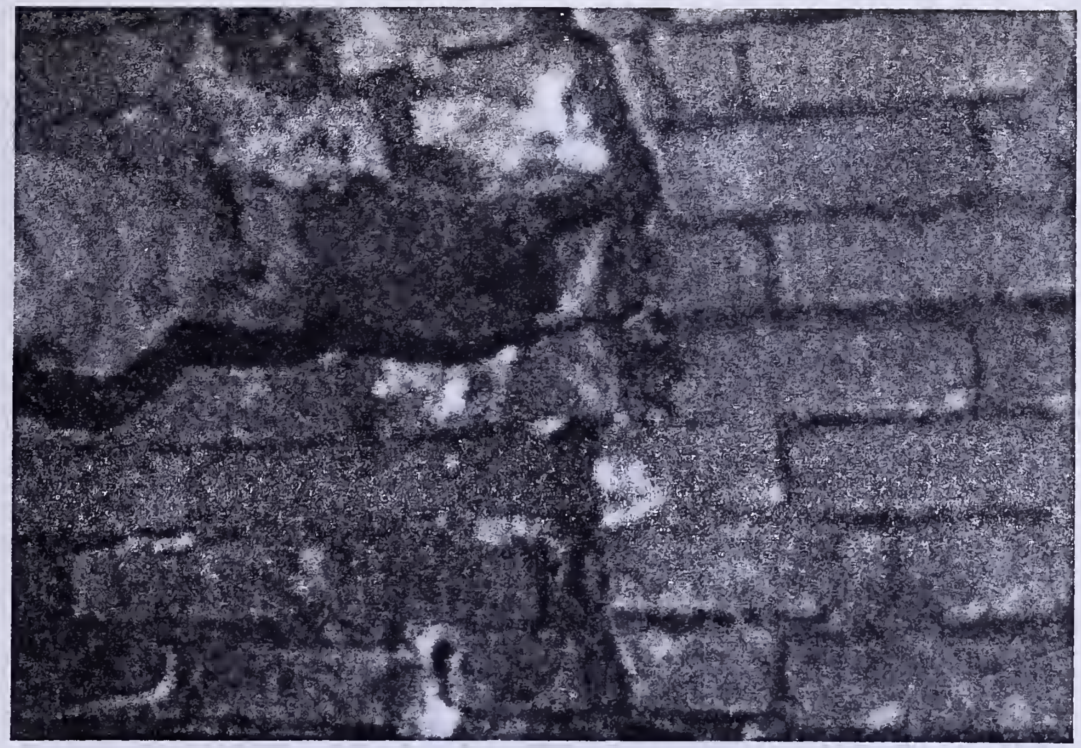
Typical Brick Arch
Negative Index #10



Replacement Section
100 ft. South of Mercury St.
Negative Index #2



Replacement Section
40 ft. South of Silver St.
Negative Index #4



Crack in Masonry
South of Aluminum Street
Negative Index #12

Crack in Masonry
South of Aluminum St.
Negative Index #11

Sewer Choked Down to Smaller Section
500 ft. South of Iron Street
Negative Index #19

Appendix C

AIR QUALITY/HEALTH INVESTIGATION
ABANDONED HARD ROCK MINES
BUTTE-SILVER BOW COUNTY, MONTANA

Submitted to

HYDROMETRICS

2727 Airport Road

Helena, MT 59601

Submitted by

Floyd C. Bossard & Associates, Inc.

P. O. Box 3837

Butte, MT 59702

FINAL REPORT

Submitted February 10, 1984

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I. SUMMARY AND CONCLUSIONS

Mortality and morbidity studies have indicated that Butte's population has a higher than normal incidence of lung cancer and respiratory system diseases. The Montana Air Pollution Studies (MAPS) were mandated and funded because of unusually high death rates from chronic pulmonary disease and lung cancer in several Montana counties and because many scientists and researchers feel that increased air pollution levels may cause or contribute to the severity of certain lung diseases. The Montana Air Quality Bureau recommended the extensive study to determine the association between air pollution and human health.

The MAPS studies concluded that children with the poorest pulmonary function performance were exposed to the highest levels of particulates and sulfur dioxide. Also, adults with chronic obstructive pulmonary disease had decreased pulmonary function and increased coughing, wheezing and breath shortness with increasing air pollution levels. Butte children showed elevated urine mutagen levels specifically in certain areas of residence. The etiology of the diseases were not defined; however, a review of death certificates and records revealed statistically significant high death rates from asthma, chronic bronchitis, emphysema, cerebrovascular disease, and lung cancer in Silver Bow County. Death rates due to cancer of the respiratory system in Silver Bow County were almost eighty percent (80%) greater than the Montana death rate per 100,000 population for 1969-73. For the same period, respiratory diseases were more than fifty percent (50%) higher than the corresponding Montana rate.

Community air pollution appears to contribute to the excess disease and death rates. Overall, the MAPS program confirmed the proposition that there is an association between air pollution and pulmonary performance. Increased air pollution levels cause a decrease in lung function (33).

Epidemiological studies of children and general adult populations have lead scientists and researchers to make the following conclusions or statements:

1. There is a definite relationship between the environment, including weather and air quality, and chronic obstructive disease and pulmonary function. The relationship is too complex to point to one specific factor or pollutant (1, 11, 52).

2. Smoking, air pollution and the introduction and use of new industrial and agricultural chemicals in man's environment are responsible for the increasing incidence of lung carcinoma (1, 5, 9, 12, 13). There is a definite association between community air pollution and increased mortality rates due to cancer of the respiratory tract.

3. The effects of air pollution on the respiratory system of children is of great consequence. Significant changes in lung function at an early stage in life may increase the risk for subsequent respiratory disorders later in life. There is considerable evidence linking childhood air pollutant exposure and decreased ventilatory function (50, 5).

4. In the long term, continued chronic exposure to significant air pollution increases the risk of serious respiratory illness in children. Moreover, certain air pollutants may affect some aspects of human growth and development (4, 5).

5. Two to three percent of all human congenital malformations may be attributed to drugs and environmental chemicals. Moreover, some chemicals or pollutants may predispose a fetus to congential or postnatal disease. Thus, prenatal pollutant exposure may condition an individual's potential risk to developing cancer or other disease later in life. Such a suggestion is significant to the public health of a population (14).

Arsenic, cadmium, chromium, and nickel are all present in the Butte environment and all have been implicated as human carcinogens and, with the exception of arsenic, have induced cancer in animals. Iron, lead and zinc are suspect human carcinogens and have caused cancer in experimental tests. These metals are also present in the ambient Butte environment. Free silica is also present in high quantities in Butte's ambient dust and a distinct relationship between iron dust and free silica has been documented. Inhalation of iron dust causes a benign pneumoconioses called siderosis. However, if other dusts,

dusts, particularly free silica, are present, fibrotic pulmonary changes occur. Thus, the presence of free silica in addition to iron induces more significant lung changes. This additive or possibly synergistic relationship is significant in an ambient situation where both contaminants occur together and in the presence of even more pollutants.

The community of Butte-Silver Bow has a statistically high rate of respiratory and circulatory disease and death. The preponderance of evidence indicates there is a strong correlation between air pollution and disease of the respiratory system.

The presence of potential human carcinogens; the potential for additive or synergistic toxicologic reactions between the air pollutants; and the potential or actual chronic long-term public health exposure are matters of significant concern. These factors, coupled with the increased incidence of lung carcinoma in Butte-Silver Bow and the definite association between community air pollution and high respiratory disease and cancer in the literature, weigh as heavy circumstantial evidence of the potential public health concern present in Butte.

The cause of cancer is, at our current knowledge level, a multiplicity of factors. Some urban pollutants have known carcinogenic potential. Additionally, many air pollutants are respiratory irritants and may facilitate the deposition and subsequent reaction of carcinogenic compounds. Irritants may provide sensitive sites on the respiratory tract.

The presence of carcinogens, their deposition and retention in the respiratory system and individual factors of susceptibility are important parameters in cancer development. However, at what level or concentration environmental carcinogens must be present in order to induce cancer is not known. Most researchers and scientists feel only minute concentrations of a carcinogen are necessary to disease development. But the toxicologic implications of

environmental pollutants in general and specifically carcinogens are very undefined. In order to protect public health, it is probably appropriate to take a very conservative approach in evaluating the consequences of ambient pollutant exposure.

Evidence is available to show the adverse consequences of air pollution on public health, specifically changes in pulmonary performance and lung cancer. Public health practice and preventative medicine both strive to prevent the development of disease and take adequate measures beforehand to control the progress of disease. Adequate information is available to indicate the need to control and eliminate air pollution for the betterment of any community and the public's general health.

Surface disturbances associated with the abandoned mine lands include numerous exploration trenches, waste rock dumps, and several open pits. Waste material associated with the underground mines ranges from a few hundred cubic yards up to an estimated 815,000 cy in the Mountain Con dumps. The Alice Open Pit dumps contain about 5,560,000 cy of material. The Clark Mill tailings site is estimated to contain one million tons. The surface area of abandoned mine lands studied in this report is about 350 acres.

The barren slopes of many of these waste dumps are being eroded. Some of these dump sites are contained or are partially contained by retaining walls. Most retaining walls are of wooden construction. A few are steel. All of these retaining walls require periodic replacement or repair. Most walls are in fair to poor condition. The eroded dump material is deposited on the city streets where much of it is carried into the Butte-Silver Bow storm sewer system. The material deposited on city streets is broken down into fine dust by vehicular traffic and becomes airborne due to increased air velocities from the vehicles or natural winds. The Montana/EPA agreement on management and

administration of Montana's environmental programs for 1983 (61) lists the principal sources of suspended particulate in the Butte area as the mining operations and the local streets.

Little effort has been devoted to studying the negative impact of the abandoned hard rock mine lands on the air quality of the Butte area. The primary objective of this study is to attempt to correlate the effect of the abandoned mine lands on the local air quality, which impacts the health of the Butte area citizens.

A surface dust sampling and chemical analysis program was conducted at sixteen locations in the study area that are potential contributors to airborne dust. The original sources of the dust are abandoned mine land areas. The chemical analysis of the fraction of the dust that could become airborne, along with an assessment of the potential negative effect on the health of the local population indicate strong support for eliminating erosion of abandoned mine lands that are potential contributors of toxic contaminants into the ambient air. Significant concentrations of arsenic, chromium, iron, manganese, lead, zinc, free silica, and sulfate were found in the street dust below the following mine dumps:

1. Ophir Mine
2. Anselmo Mine
3. Emma Mine
4. Original Mine
5. Mountain Con Mine
6. Travonia Mine/Star West Dump Area

Therefore, a stabilization/reclamation program is recommended for these mine dumps in order to reduce the amount of material eroded from the dumps and deposited on the city streets.

An engineering/reclamation plan should be developed for each of the above dumps with the objectives of eliminating precipitation and wind erosion effects on the dumps by (1) stabilizing the slopes and revegetating the surface or (2) removing all or portions of the dumps and reclaiming the surface.

Additionally, further review of the potential air pollution impact of the following abandoned mine land areas should be pursued:

1. Colorado Mine Dump
2. Buffalo Mine Dump
3. Clark Tailings Area

Additional street dust samples should be obtained from below the Colorado and Buffalo Mines and analyzed for toxic elements. These two mine dumps are vulnerable to erosion, resulting in the deposition of material on streets where vehicular traffic can pulverize the dirt into dust. The dust then becomes airborne due to traffic and wind.

The dust sample obtained from the Clark Tailings does contain significant concentrations the toxic elements arsenic, iron, manganese, lead, zinc, sulfate, and free silica. The role of the contribution of the Clark Tailings Area to local air pollution problems is not clear at this time and has to be defined in greater detail.

Approximately 60 percent of the population living adjacent to the abandoned mine land areas and who responded to a socioeconomic survey indicated that the abandoned mine land sites in their neighborhood were a source of dust. The responses indicated that the sources of dust from these mine areas are (1) wind-blown and/or (2) material eroded from the mine dump areas, deposited on down-grade sites and entrained into the ambient air by other community activities and natural forces.

Short-lived, radioactive radon-daughters which deposit and decay in the human respiratory system are a potential cause of lung cancer. The Montana Department of Health and Environmental Sciences has conducted a field study and investigated the potential sources of radon gas (radon-222) which contribute to the elevated ambient and indoor concentrations of radon and radon-daughters in Butte, Montana (67).

Ambient air, soils and surface geology all contribute to the indoor radon problem in Butte. It is believed that homes constructed over major fractures or mineralized veins are the most severely affected. Mineralized veins and fractures may act as conduits for transport of radon gas.

It is possible that ambient air is a significant source of indoor radon during certain atmospheric conditions in structures having no other substantial source of radon. The study did not provide any information on the specific contribution of abandoned mine lands to the radon gas problem of Butte. But the data would imply that it may be appropriate to study this aspect further.

The following are additional recommendations submitted as a result of this study:

1. Conduct an expanded street dust sampling and chemical analysis program in the Butte community approximately north of Silver Bow Creek.

2. Conduct a detailed soil sampling program in residential areas and abandoned mine land areas to determine background levels of toxic chemical constituents present.

3. Expand the chemical analysis of total suspended solids collected at local air monitoring stations to include toxic metals, sulfate and free silica.

4. Conduct an ambient air sampling program in residential areas proximate to abandoned mine lands that are contributing to the air pollution of Butte. it is important to identify all constituents in the suspended particulates in order to attempt to understand their potential synergistic effect upon the health of the local population.

5. Conduct an epidemiological study in Butte to

    a. Determine if the incidence and causes of mortality and morbidity are in any way associated with the neighborhood of primary residence.

    b. Conduct a follow-up study of Butte children who are exposed to known or suspected health hazards resulting from environmental air pollution. Progressive changes in health and latent effects should be documented and studied.

II. INTRODUCTION

Available air quality data in association with the environmental health, and directly the related personal health statistics of the local population, were examined for the Butte area. Past Butte air quality studies have done little to analyze the contribution of the Abandoned Mine Lands (AML) in the Butte area as a source of airborne dust.

Portions of Butte-Silver Bow County have been designated as an air quality non-compliance area since 1978 by EPA and the Montana Department of Health and Environmental Sciences. Specifically, the ambient air quality for particulates in certain areas of the county do not meet EPA standards. This study examined chemical constituents of sampled airborne particulates as well as potential airborne dust that could originate from the AML areas.

Mortality and morbidity studies have indicated Butte's population has a higher than normal incidence of lung cancer and respiratory system diseases. Limited epidemiological studies were conducted on Butte school children during the recent Montana Air Pollution Study. This report reviews these studies.

Surface mining, milling and tailings disposal operations in Butte were suspended on June 30, 1983. This action eliminated point source dust emissions from:

1. Drilling and blasting
2. Truck loading
3. Truck haulage of ore and waste
4. Dumping waste over the edge of waste dumps
5. Dumping of ore into crusher hopper
6. Ore crushing, conveying and grinding operations.

Dust sources from the exposed open pit, waste dump and tailings pond still exist. Effects of the suspension were not examined as part of this investigation. However, air quality studies conducted when mining was active in Butte clearly identified a relationship between mining activities and air quality degradation from airborne particulates.

The HYDROMETRICS proposal did not provide funding for conducting additional ambient air quality sampling programs for long-term monitoring. Only the historical air quality information available was evaluated.

The study was conducted by dividing the work effort into six tasks, including:

TASK 1 - REVIEW AVAILABLE PUBLISHED REPORTS

TASK 2 - REVIEW UNPUBLISHED AIR POLLUTION INFORMATION FROM THE ANACONDA MINERALS COMPANY AND MERDI/MULTITECH

TASK 3 - CONDUCT A PROGRAM OF VACUUM COLLECTION AND CHEMICAL ANALYSIS OF POTENTIAL AIRBORNE DUST

TASK 4 - INTERFACE WITH THE MONTANA AIR QUALITY BUREAU

TASK 5 - ANALYZE AND SUMMARIZE INFORMATION ON AIR POLLUTION GAINED FROM SOCIOECONOMIC QUESTIONNAIRE

TASK 6 - WRITE FINAL REPORT

III. BACKGROUND INFORMATION

A. History of Air Pollution From Mining Operations

The Butte mining district was discovered in the early 1860's with the initiation of placer mining operations. By 1864, one thousand men were involved in gold and silver placer mining operations along Silver Bow Creek. In 1866, the first underground lode mining operation for silver was started.

The first furnace was constructed in 1867 to treat silver/copper ore from the Parrot Mine. In 1868, the Davis mill and furnace were constructed to treat and smelt silicous silver ores. However, the facilities were unsuccessful and abandoned. By 1868, the rich placer operations had played out and the population of Butte had shrunk to about one hundred.

By 1875, successful silver lode mining, milling and smelting techniques had been developed and Butte's population had expanded to about four thousand inhabitants. A railroad from Odgen, Utah to Butte was completed in 1881.

Marcus Daly encountered copper glance (chalcocite, 55% copper) on the 300 level of the Anaconda Mine. In 1884, the first copper reduction works (smelter) was constructed in Anaconda, Montana.

A major contributor to the degradation of air quality in Butte has been activities associated with over 100 years of mining. Primary examples are:

1. Concentrators and smelters operated in Butte during the late nineteenth century and early twentieth century. Emissions from these plants included copious amounts of sulfur dioxide, arsenic trioxide and oxides and sulfides of many other heavy metals.

2. There were about 175 underground mines in Butte around the turn of the century. This number had decreased to about 25 operating mines during World War II. All underground mining operations ceased in the mid-1970's. Activities of these mines resulted in the production of thousands of tons of ore per day, the dumping of millions of tons of waste material on the surface (waste dumps), and a general disturbance to hundreds of acres of surface land, some of which remain barren or poorly vegetated.

3. The initiation of open pit mining operations in the late 1950's left unreclaimed open pits and waste dumps such as the Alice Pit in Walkerville, the Syndicate Pit in the northwest section of Butte, as well as the well-known Berkeley Pit and the East Berkeley Pit. No reclamation efforts have been devoted to either the Alice or Syndicate Pits, which are surrounded by urban development.

In 1978, Historical Research Associates (HRA) wrote a report on a historical emission inventory of Butte for the Montana Air Pollution Study (34). Most of the following information in this section of the report originated from the HRA effort.

In the early history of Butte, the most significant sources of industrial air pollution were the concentrators and smelters that processed locally mined ores. The toxic gases, vapors and fumes emitted from the smelting operations either poisoned the local soil, killed most of local vegetation or seriously impaired the quality of the soil and vegetation depending on the distance and prevailing direction from the smelters.

Air pollution problems were prevalent in the 1870's and 1880's. Much of the pollution was the result of a metallurgical operation called "heap roasting." Heap roasting consisted of dumping the very rich sulfide ores onto a several-foot layer of cordwood. The wood was then torched, igniting the sulfur in the ore and resulting in the expelling of sulfur dioxide, arsenic oxide and other fumes. The ore pile usually burned and smoldered for a month or more before the combustion operation diminished sufficiently for removal and shipment or smelting of the roasted product. Matte assaying up to 60 percent copper and 700 to 800 ounces of silver per ton was produced by heap roasting.

The serious negative impact on local air quality resulted in the Butte City Council passing Ordinance No. 186 in December 1890. Open heap roasting was declared a public nuisance and economic penalties were imposed on anyone using the process within three miles of the city. However, roasting with the

use of chimneys was permitted. The confined roasting of ores and emission of gases via stacks resulted in a more efficient combustion process. On the other hand, it did little to reduce the total sulfur dioxide and heavy metal emissions because there were no air pollution control devices installed in the off-gas stream. Some nominal reductions in emissions occurred if flue dusts were recovered. Butte natives testify it has taken decades for the local soil and vegetation to make a comeback from the devastation wrought by heap roasting and early smelting operations. Table 1 contains a list of the principal metallurgical plants (involving milling and smelting) that have operated in Butte.

Mills that incorporated crushing/concentrating equipment to upgrade ore were constructed in Butte to supplement the rich, direct-smelting ores fed to the smelters. A list of some of the milling operations and start-up and closure dates includes the following:

Operation	Start-up Date	Closure Date
Alice	1877	N.R.
Colusa Smelter of Montana Copper Co.	1878	1902
Colorado	1882	1909
Parrot	1882	1902
Butte and Boston	1896	1909
Butte Reduction Works	1907	N.R.

This is only a partial list of mills operating in Butte during these years. In addition to contributing to air pollution, it was not uncommon for the early operations to discharge the waste tailings product into Silver Bow Creek, which empties into the Clark Fork River. This practice resulted in the degradation of Silver Bow Creek and portions of the Clark Fork River for some 100 plus miles downstream. By 1910, the principal metallurgical operations conducted in Butte had been transferred to the Washoe Smelter in Anaconda, Montana.

TABLE 1. REPORTED COPPER PRODUCTION FROM BUTTE SMELTERS

Production, Thousands of Pounds of Matte or Blister Copper

	Name of Plant	1883	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894
1.	Butte & Boston Smelter							1,103	5,358	N.R.	10,641	20,458	57,938
2.	Boston & Montana Smelter		6,600	7,500	2,000	1,500	18,979	56,425	26,823	N.R.	30,387	31,800	a
3.	Clark's Colusa Smelter		600	10,000	7,000	7,100	7,000	b	b	N.R.	b		
4.	Montana Ore Purchasing Smelter											8,400	12,294
5.	Colusa-Parrot Smelter		2,000	2,500	1,700	1,565	3,522	2,560	3,300	N.R.	2,864	2,985	2,282
6.	Colorado Smelter			1,200	N.R.	1,500	1,488	2,400	2,320	N.R.	4,561	6,704	5,159
7.	Colusa Smelter, Montana Copper Co.		No Production Figures Available										
8.	Parrot Smelter	6,600	9,300	9,809	10,000	10,000	10,750	9,500	9,000	N.R.	12,439	7,791	7,470
	TOTAL	6,600	18,500	31,009	20,700	21,665	41,739	71,988	46,801	N.R.	60,892	78,138	86,143

a. Listed jointly with Butte and Boston Smelter

b. Listed jointly with Boston and Montana Smelter.

Reference: Montana Air Pollution Study: Preliminary Investigations, Historical Emissions Inventory. Historical Research Associates, July 1, 1978.

1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909
60,746	4,500	N.R.	7,000	79,000	16,950	58,029	10,000	N.R.	N.R.	N.R.	N.R	9,210	10,350	14,011
a	60,250	60,000	62,000	a	66,200	a	75,000							
14,861	15,049	13,048	13,084	15,361	22,258	29,899	30,650							
3,390	4,226	7,884	9,685	10,050	12,456	17,970	19,400							
7,750	9,019	8,912	7,658	9,572	11,454	7,500	10,000	N.R.	N.R.	N.R.	N.R.	6,794	6,230	8,547
7,257	8,046	14,824	12,445	10,625	N.R.	10,168	10,000							
94,004	91,162	104,668	111,872	124,609	129,318	123,566	155,050	N.R.	N.R.	N.R.	N.R.	16,004	16,580	22,558

Other metallurgical plants that operated in Butte at later dates include:

1. Timber Butte Mill (owned by W. A. Clark interests). This plant was located on South Montana Street (on the north slope of Timber Butte). It had the capacity to treat 2000 tons per day (tpd) of zinc ore and operated from about 1914 to 1918, according to available records.

2. Domestic Manganese Plant: This smelter was located at South Montana and Front Streets. It was capable of treating 500 tpd of crude manganese ore and operated in 1928-29 and during World War II. It was converted to an animal phosphate food supplement plant and operated as such from 1956-58. During this period, the plant was guilty of discharging substantial amounts of fluorides into the ambient air. The rotary kiln was later used by the Anaconda Company to produce slaked lime.

Both of the above plants have been dismantled.

Public utility plants that were fueled with wood, coke or coal while operating in the early years of Butte include:

1. Alice Mine Power plant (1880-?)

   Twenty horsepower electric generating plant.

2. Clark Power Plant (1882-1890?)

   Two hundred and twenty horsepower electric power plant.

3. Butte Gas, Light and Coke Company (1884-1918?)

   Converted 25 tons of coal daily to coal gas and coke.

A newspaper article written in 1882 listed the following consumption of cordwood in Butte:

1. 5,000 cords/month, Smelting Operations
2. 3,000 cords/month, Mining Operations
3. 2,000 cords/month, Domestic Consumption

Approximately 1200 to 1500 persons were employed as wood cutters during this period. These production figures probably increased as mining and smelting activities increased in the 1880's.

The Butte underground mining operations produced 15,000 to 20,000 tpd from selective vein and block cave mining operations in the 1950's but declined after the start-up of the Berkeley Open Pit and ceased entirely in the mid-1970's.

The Berkeley Pit, which started up in the 1950's, mined up to a quarter of a million tons per day of ore, low-grade leach material and waste. Mining in the Berkeley complex was suspended in June 1983.

Copper ore concentrating facilities at the Anaconda Reduction Works (Washoe Smelter) were replaced by the 35,000 to 40,000 tpd capacity Weed Concentrator built in the early 1960's in Butte. Operation of this Butte concentrator was suspended in June 1983.

B. Site Description

The majority of abandoned mine lands included in this study are located in the northwest portion of the Butte City boundaries (west of Arizona Street and north of Front Street). Some abandoned mines between Second Street and Mercury Street (from the Belmont Mine area and west) were included. The study also included the old Clark Mill Tailings and the Alice Open Pit in Walkerville.

Surface disturbances associated with the abandoned mine lands include numerous exploration trenches and waste rock dumps and several open pits. The volume of waste material associated with the underground mines ranges from a few hundred cubic yards up to hundreds of thousands of cubic yards (estimated at 815,000 cy in the Mountain Con dumps). The Alice Open Pit dumps contain about 5,560,000 cy of material. The Clark Mill tailings disposal site is estimated to contain one million tons (63).

The surface area of abandoned mine lands studied in this report is about three hundred and fifty acres and is comprised of the following:

Acres	
220	Underground Mines
46	Alice Open Pit Operations
22	Syndicate Open Pit Operations
62	Clark Mill Tailings
350	Total Area, Abandoned Mine Lands

The barren slopes of many of these waste dumps are being eroded. Some of these dump sites are contained or are partially contained by retaining walls. Most retaining walls are of wooden construction. A few are steel. All of these retaining walls require periodic replacement or repair. Most walls are in fair to poor condition. The eroded dump material is deposited on the city streets where much of it is carried into the Butte-Silver Bow storm sever system. The storm sewers discharge into Silver Bow Creek. The material deposited on city streets is broken down into fine dust by vehicular traffic and becomes airborne due to increased air velocities from the vehicles or natural winds.

There has been somewhat of a local technical concensus that dust problems from old waste dumps is minor where the dump surface has developed a crust. On closer examination, even crusted dumps erode, resulting in the depositing of dump material on the streets.

Air quality problems associated with the Butte abandoned mine lands have not been clearly defined. Some dust problems from wind erosion have been reported by investigators and the local populace. However, these reports are subjective, not qualitative.

The elevation of the study area ranges from about 5100 feet to 6400 feet. The Summit Valley area (a Cretaceous lakebed) extends about five miles south of the City of Butte. The Butte/Summit Valley area is bounded on the east and south by the Continental Divide.

The surrounding peaks make the area susceptible to temperature inversions. Due to the high elevation, summer arrives late and the fall temperatures usually

usually come early. Precipitation is variable, ranging from 6.4 to 20.6 inches annually, averaging 11.5 inches annually since 1951.

From a natural air pollution standpoint, the background airborne particulate levels include windblown dust, biological debris and atmospheric aerosols. Man-made and natural emissions transported from long-range are also considered background contributions, since local control will not eliminate these particulates.

Airborne particulates have been sampled in locations chosen as representative of background sites. The Richer residence in Walkerville recorded annual arithmetic mean concentrations of 23 $\mu g/m^3$ for 1975-1976 and 22 $\mu g/m^3$ for 1977 (45). Similar studies conducted for the Montana Energy and MHD Research and Development Institute indicate that the background levels for airborne particulate is about 20 $\mu g/m^3$ in the southern end of Summit Valley (37).

The Montana/EPA agreement on management and administration of Montana's environmental programs for Federal Fiscal Year 1983 (61) lists principal sources of suspended particulate in the Butte area as the mining operations and the local streets. Street dust becomes airborne because of traffic patterns and wind action. All active mining operations were suspended on June 30, 1983. However, the permitted mine area will continue to contribute some particulate to ambient air because of nature's forces acting on unreclaimed surface disturbed by open pit mining operations.

A review of the literature indicates little effort has been devoted to studying the impact of the abandoned hard rock mine lands on the air quality of Butte. A large portion of the area of northwest Butte and Walkerville consists of exposed, unreclaimed land from abandoned mining operations.

C. Climate and Meteorology

Butte, at an elevation of approximately one mile, is located in a relatively sheltered mountain valley on a slope in the Rocky Mountains. The Continental Divide lies two miles to the north and east and about twelve miles to the south.

From the period of late fall to early spring, the city and Summit Valley experience frequent periods when surface winds are very light and also when inversion conditions exist (1). Winds in Butte are less than seven miles per hour 58 percent of the time throughout the year and 64 percent of the time in the fall and winter. Calms occur 17 percent of the time. Butte area winds tend to be light in velocity and circular in pattern, factors which contribute significantly to the high incidence of temperature inversions and the buildup of air pollutants.

A climatic factor contributing to temperature inversion is the cold air drainage into Summit Valley from the surrounding mountains. In winter, this cold air drainage, along with radiation from snow-covered surfaces, may produce temperatures from 15 to 20 degrees colder at the airport than in the city about 200 feet higher in elevation. During the fall/winter months, a strong inversion is frequently observed over Butte and Summit Valley.

Summer maximum temperatures infrequently reach 90°F. There have been very few occurrences of a 100°F maximum temperature. Zero degrees Fahrenheit temperatures have been recorded as early as October and as late as April; and the average number of occurrences is about 45 per year. Periods of severe cold may occur from November through March. But these periods are normally of short duration and are usually followed by warmer weather as a result of invasions of warmer air.

D. Objectives

The community of Butte/Silver Bow has a statistically high rate of lung cancer and respiratory and circulatory disease and death. The preponderance of evidence indicates that there is a strong relationship between air pollution and disease of the respiratory system. The lung cancer rates experienced in Butte/Silver Bow County have not been definitively related to air pollution, but the possibility cannot be ignored or excluded (2).

The primary objective of this study is to attempt to correlate the effect of the abandoned mine lands on the local air quality, which impacts the health of the Butte citizens.

The Office of Surface Mining's interpretation of the rules and regulations pertaining to PL 95-87 SMCRA indicates that a clear threat to public health or safety must be proven if the reclamation of non-coal abandoned mines is to be funded by OSM. Physical stockpiles of waste and low-grade material, barren tailings piles and abandoned surface and underground mines by themselves do not constitute a clear threat to human health. Therefore, an effort was made to define the air pollution potential of abandoned mine lands that pose a definable threat to public health.

Abandoned mine lands studied include:

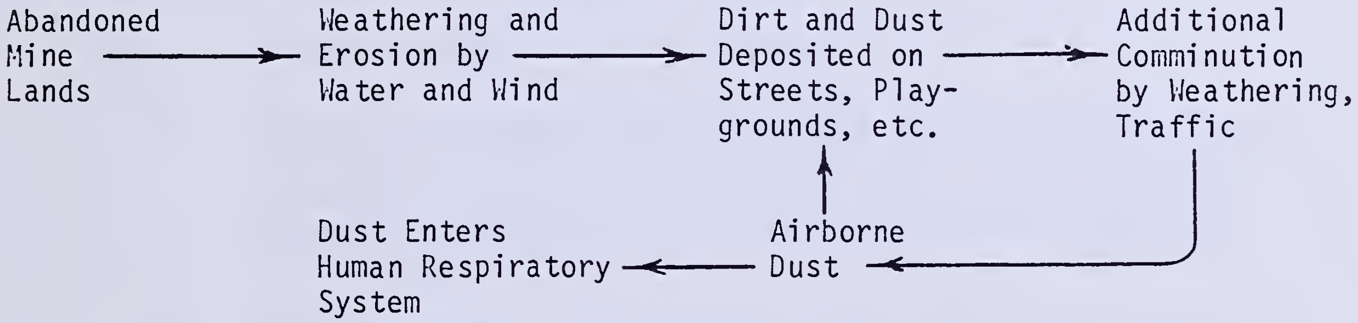
1. The Clark tailings,
2. Barren waste and low-grade dumps,
3. Inactive surface mines and dumps, and
4. Inactive surface mine dumps from underground mining operations.

Abandoned mine lands in Butte have not been clearly linked with air quality degradation and health problems in Butte by previous investigators.

Efforts in this investigation were directed toward:

1. Defining ambient air quality problems in Butte,
2. Summarizing the health problems in Butte that may be associated with air pollution,
3. Identifying potential toxic elements or agents present in Butte surface dust that could originate from abandoned mine lands. The fraction of the dust that could become airborne was chemically analyzed for toxic constituents, and
4. Identifying specific AML areas contributing to Butte air pollution problems.

A proposed simplified mechanism of abandoned mine lands contributing to airborne dust is:


Abandoned Mine Lands
Weathering and Erosion by Water and Wind
Dirt and Dust Deposited on Streets, Playgrounds, etc.
Additional Comminution by Weathering, Traffic
Airborne Dust
Dust Enters Human Respiratory System

A scenario of how mine dump waste deposited on the Butte city streets contributes to air pollution is presented.

1. Precipitation (snow or rain) washes waste dump material onto city streets (discussions with J. Johnson, Public Works Director, 65).
2. Vehicular traffic pulverizes the deposited waste material (assisted by weathering).
3. The fine dust becomes airborne due to traffic and natural winds.
4. A closed cycle of dust entrainment, settlement and reintrainment in the ambient air can develop because the streets are not washed and swept after each precipitation event.

A modest amount of dump material deposited onto city streets could result in significant increases in airborne dust, especially in the immediate area.

The study involved an extensive review of Butte area air quality data. The purpose of the review was to determine possible relationships between abandoned mine lands and human health in the study area. An effort was made to identify specific AML sites that could have a negative impact on the health of the local population.

E. Work Tasks Pursued

The project timetable did not provide funding for development of a long-term ambient air quality monitoring and chemical analysis program. Therefore, only historical air quality information available was evaluated.

The study consisted of six separate tasks:

TASK 1 - REVIEW AVAILABLE PUBLISHED REPORTS

a. Over sixty reports and publications have been identified as pertaining to (1) Butte air quality and (2) health aspects of Butte residents. These reports were reviewed and air pollution/health aspects pertinent to the AML Study were reported on.

b. The toxicology of heavy metals, free silica and sulfate which are present in Butte ores and may be present in Butte airborne particulate was reviewed and described.

TASK 2 - REVIEW UNPUBLISHED AIR POLLUTION INFORMATION FROM THE ANACONDA COMPANY, MERDI/MULTITECH AND HYDROMETRICS

a. Both The Anaconda Company and the Montana Energy Research and Development Institute have conducted ambient air quality surveys of the Butte area. Much of this information has not been published. Approval was received from both organizations to review their data base and obtain information pertinent to the AML Study.

b. HYDROMETRICS conducted work for The Anaconda Company pertinent to air pollution, including:

(1) Taking thirteen samples of soils from inactive waste dumps in the Butte area.

(2) Taking soil samples and assessing air quality impacts of the Clark Tailings.

c. Another source of information was the Butte-Silver Bow County Health Department.

TASK 3 - CONDUCT A PROGRAM OF VACUUM COLLECTION AND CHEMICAL ANALYSIS OF POTENTIAL AIRBORNE DUST

a. A composite sample of fine surface material was collected from the Clark Tailing by using an industrial vacuum cleaner and portable electric generator.

b. Composite samples of fine surface material from three playgrounds adjacent to and downhill from abandoned mine lands were collected with an industrial vacuum cleaner and a portable electric generator.

c. Twelve samples of fine surface material from streets adjacent to and downhill from twelve major abandoned mine areas were collected by using a Butte-Silver Bow County street sweeper.

d. All sixteen samples were screened in various sizes down to and including a minus 45 micron fraction. The minus 45 micron fraction will become airborne due to vehicular traffic and natural wind conditions. This type of airborne particulate could be inhaled by the local population.

e. The minus 45 micron fraction was analyzed for As, Bi, Ca, Cd, Cr, Cu, Fe, Mn, Ni, Pb, Zn, sulfate, free silica, and total non-volatile hydrocarbons (HC). Some of these contaminants can be considered toxic to human health. All but HC can be present in the Butte ores, and hence associated with the abandoned mine lands. Lead can also be derived from auto exhaust emissions.

TASK 4 - INTERFACE WITH THE MONTANA AIR QUALITY BUREAU

a. Meetings were held with Air Quality Bureau personnel. The AQB provided unpublished information on various aspects of Butte air pollution.

b. Available information was obtained and reviewed in an effort to identify data pertinent to the AML air quality/health investigation.

c. A specific effort was made to determine if information is available on the chemical analysis of airborne particulate samples taken in Butte by the AQB.

d. A review was conducted of the Historical Emissions Inventory Report developed by Historical Research Associates for the Montana Department of State Lands.

TASK 5 - ANALYZE AND SUMMARIZE INFORMATION ON AIR POLLUTION GAINED FROM SOCIOECONOMIC QUESTIONNAIRE

a. Econsult Inc. of Butte incorporated a question pertaining to air pollution in a socioeconomic questionnaire that was distributed to about 150 persons living adjacent to abandoned mine lands in Butte.

b. Responses to the air pollution question were evaluated and are discussed in this study.

TASK 6 - FINAL REPORT

IV. PERTINENT HEALTH ASPECTS OF BUTTE-SILVER BOW COUNTY RESIDENTS AND EPIDEMIOLOGICAL STUDIES

As more and more studies are being made on the effect of air pollution on public health, a definite association between community air pollution and lung cancer, chronic bronchitis, asthma, emphysema, and heart disease is being found. Acute episodes of pollution exposure are well documented, such as those which occurred in the Meuse Valley of Belguim in 1930; in London in both 1948 and 1952; and in Donora, Pennsylvania in 1948. Several thousand persons died during these disasters and thousands became ill. As the knowledge base, technology and regulation expands, the potential for major air-pollution caused disasters should be alleviated or minimized.

Chronic, long-term effects of air pollution on human health are more difficult to document and are now of greatest concern. Studies have clearly shown a relationship between air pollution and health degradation. Such a relationship is very complex and difficult to determine. Not only may certain airborne contaminants interact synergistically with one another, but certain climatic conditions facilitate pollution conditions. The effect of any given pollutant may be modified by the presence of another pollutant as well as by varying meteorological conditions.

One approach to evaluating any relationship between environmental pollution and community health is to determine whether or not the pollutant is present in concentrations that will contribute to the incidence and severity of a disease. Another approach is to study the health of a particular population and to determine the causative agent(s) of morbidity or mortality. Whichever approach is used, both can show a relationship between air pollution and the degradation of public health if it is occurring.

A. Epidemiological Studies of the Effects of Air Pollution on Butte Residents

Unusually high death rates from chronic pulmonary disease and lung cancer occur in several Montana counties of which Silver Bow is one. This information and the fact that many researchers and scientists feel that these categories of lung disease or cancer are caused or increased by high levels of air pollution have lead to air pollution and health research studies in Butte-Silver Bow.

Butte physicians John A. Newman and Raymond D. Grondahl of Butte and five other researchers, studied microscopic slides prepared from lung carcinomas of residents of Deer Lodge and Silver Bow counties (40). They conducted a "blind study." The pathologists did not know the residence or occupation of the individual from whom each specimen was taken. Slides were examined separately and interpretations compared.

Newman, et al. (40) concluded that cancer of the bronchus and lung cancer are elevated among Butte and Anaconda men and Butte women. The respiratory cancer rate for Anaconda women was also elevated, but the number of observed deaths was inadequate to provide statistical significance.

Because of the distribution of various types of lung cancer among smelter workers and because of elevated lung cancer rates in Anaconda women, Newman, et al. suggest the excess cancer death rate among Anaconda men and women is caused by the same airborne contaminant and that this agent or agents is present both in the occupational setting and community environment. They further suggest that this etiologic agent is airborne arsenic and the source is the Anaconda copper smelter.

Because the type of cancers found in Anaconda smelter workers and Butte miners are different, a common etiologic factor may not be the case. Additionally, the concentration of arsenic and type of arsenic found in the ores

mined differs from the smelter. Moreover, Butte miners and other Butte men experienced similar histologic type distribution of lung cancers. For these reasons and the fact that Butte women experience excess lung cancer, it is possible to state that:

1. Excess lung carcinoma among miners is not due to radiation emissions from radon daughters underground. The histologic type lung cancer is not that associated with radiation exposure.
2. The cause of excess bronchogenic lung cancer among both men and women in Butte suggests that the causative agent is possibly community air pollution.

Newman, et al. propose for consideration that although radon daughter radiation emissions and airborne arsenic may not be the primary etiologic factor in Butte's excess lung cancer, several other sources of community air pollution cannot be ruled out. These are emissions from previous smelting activities in Butte at the turn of the century and sanding material used on city streets during the winter months for vehicular and pedestrian travel.

Previous Butte mining history indicates that as many as seven copper smelters may have operated within and around Butte. One of the most serious sources of pollution was open-air roasting of ore called heap roasting. This was the first phase of a smelting process and these heaps burned and smoldered for weeks, releasing toxic smoke and fumes composed of oxides of sulfur and arsenic, particulates and fluorides. Eventually, residents became concerned with an association between death and disease in the community and there was a public outcry to improve the environment and control the air pollution. However, the contaminants released were deposited in the Butte valley and may still be a source of community air quality and a public health concern.

Sanding of Butte streets is of concern because of the particulate size, chemical makeup and distribution. A large fraction of the sanding material is of respirable size, meaning that it is small enough to gain access to the inner reaches of the respiratory system, and it is crushed even smaller as vehicles drive over it.

The sand material is primarily a granodiorite and contains high amounts of free silica; some of these silicates are similar to asbestos in chemical composition. The histological distribution of cancer types among Butte miners, women and "other" men correlates with cancer types occurring in asbestos workers. Additionally, the local sand material may contain the metal contaminants deposited in the area from previous smelting activities.

As part of the Montana Air Pollution Study (MAPS) on the effects of air pollution on human health, Butte and various groups of its residents were involved in three studies performed during the project. These were (1) a pulmonary function testing of school children; (2) a screening program to determine whether the presence of mutagenic substances in the urine of school children could be correlated with area air pollution; (3) a morbidity study correlating hospital admission rates with air pollution episodes; and (4) a mortality study to determine the number of deaths possibly related to air pollution during the period 1970-75 (33a, 33b, 33c, 33f, 33h).

In the pulmonary function testing study, third, fourth and fifth grade children in Anaconda, Billings, Butte, Great Falls, Missoula, and Hardin-Crow Agency were tested during the 1978-79 school year. The Hardin-Crow Agency children were tested only once; children from the other cities were tested three times. The three tests represented the seasons of fall, winter and spring. These grade school children were chosen because they are old enough

to know how to cooperate but are young enough that they are not heavy smokers nor do they have any occupational exposure.

Study results indicated that Missoula had the highest particulate levels and Anaconda the highest sulfur dioxide levels, and the children from these two cities had the worst pulmonary function performance. Great Falls children had the best pulmonary function performance and were exposed to the lowest air pollution of all five cities. Butte and Billings children fell in between. Other findings of the study were that the pulmonary function of the children exhibited seasonal variation, but Butte and Missoula children did not increase their pulmonary performance throughout the year. Possibly this is due to accumulative effects over the winter and spring. Finally, it appears that the variation in pulmonary function performance among the communities is related to the different air quality levels within those communities.

In 1978, Butte and Anaconda third and fourth grade school children voluntarily participated in a mutagen screening program. This age group was again selected because they are young enough not to be exposed to potential carcinogens from cigarette smoking or occupational exposure. Both urine samples from the children and air filters from Butte and Anaconda were analyzed for mutagenic potential.

One widely accepted theory of cancer development, the somatic cell mutation theory, contends that cancer is caused by mutation in cellular nucleic acid. If this is true, all carcinogens would be expected to be mutagens. Mutagenic changes in cellular genetic material are required to initiate the chemical changes that lead to the production of a cancer cell. The method used for testing the mutagenicity of a substance is called the Ames Test. The Ames Test was used to help determine whether or not these children are being exposed to carcinogenic air pollutants and to correlate the presence of mutagenic

substances in the children's urine with air pollution in the Butte and Anaconda areas.

Briefly, the results of the study indicated:

1. Mutagenic substances were in both the urine samples and in the particulate matter from the air filters. Further study will have to determine if there is a relationship between the mutagens present in both types of samples.
2. Fifteen percent of the Butte children (Monroe School) had significantly high levels of mutagens present in their urine.
3. Butte children with the highest mutagen levels resided relatively near Front Street.
4. Butte urine samples generally had higher mutagen levels than the Anaconda samples.
5. The particulate matter on Butte air filters was more mutagenic than that on the Anaconda samples. More data is necessary to draw any definite conclusions.
6. The finding of different mutagen levels between Butte and Anaconda urine and air samples may confirm the existing knowledge that the distribution of different histologic cancer types and risk factors for male versus female populations differ between the two cities (Newman, et al.).
7. Finally, there are at least ten metals that can be considered carcinogenic. These will be discussed in detail in the toxicology section of this report; however, both Butte and Anaconda have at least some of these contaminants present in their ambient air.

In an attempt to study the morbility caused by air pollution, hospital admission rates of individuals with respiratory diseases was correlated with

air pollution. Montana's fifty-six counties were ranked according to the estimated impact of air pollution on human health. The worse the estimated impact of air pollution on human health, the higher the ranking. Silver Bow, Missoula and Deer Lodge ranked as the only three counties falling in the "most pollution" category. There were four other possible categories. Silver Bow ranked number one in the state as the county with the most impact on human health by air pollution.

After the counties were ranked with respect to potential impact on health due to air pollution, data on the total number of hospital discharges by county and the number of hospital discharges by county for four specific diseases was evaluated. Hospital discharge rates for individuals with respiratory diseases failed to demonstrate a correlation between hospitalization discharge rates and any of the four specific illness categories. There was no relationship between air pollution levels and respiratory disease. However, this study examined hospital discharge records for only two years and made no attempt to control variables such as urban vs. rural residence, age, available medical care, or any other environmental or individual factors.

The final study that included the Butte-Silver Bow area was a mortality study to determine the relationship of air pollution and deaths during the period 1970-75. A review of Montana's health statistics for the period 1968-73 revealed that some counties had statistically significant high death rates from asthma, chronic bronchitis, emphysema, cerebrovascular disease and lung cancer, particularly in the 40-65 age group. Deer Lodge, Lake and Silver Bow counties were selected to investigate the etiology of the high death rates.

Silver Bow County death rates due to cancer of the respiratory system as compared to Montana and national death rates per 100,000 population for 1969-73 are shown below (33h):

Silver Bow County	54.3
Montana State	30.1
National	35.5

Additionally, death rates for Silver Bow County for the years 1969-73 indicated higher rates in all six disease categories for all ages as compared to Montana death rates for the same period (33h).

Disease Category	Silver Bow County Rate*	Comparison to Montana Rate
Respiratory Diseases	98.8	51% Higher
Asthma, Emphysema & Bronchitis	331.9	42% higher
Pneumonia	44.0	44% higher
Cancer of Respiratory System	54.3	80% higher
Circulatory Diseases	680.6	42% higher
Cerebrovascular Diseases	122.7	18% higher

*Deaths per 100,000 population.

Silver Bow County had death rates in almost all categories of age, sex and disease, which were higher than the corresponding Montana death rates. After reviewing the original information, a subsequent study was performed in an effort to determine the cause(s) of the high death rates.

Consequently, in the follow-up study, death certificates were reviewed for Silver Bow, Deer Lodge and Lake counties for the years 1970-75. Additional information was also gathered regarding the deceased from the closest surviving relative. This data included such parameters as smoking, occupational background and residential history. Community air pollution appears to contribute to the excess death rates, but the compounding factor of smoking was overwhelming in the study. Moreover, there may be a synergistic reaction between air pollution exposure and smoking. However, the pulmonary function testing and the mutagen screening of school children supports the hypothesis that ambient pollution contributes to respiratory disease.

Overall, the Montana Air Pollution Study (MAPS) has studied the effects of air pollution on human health in several areas of Montana and has confirmed the hypothesis that increased air pollution levels have caused a decrease in lung performance. Further studies are necessary to further delineate the association between air pollution and disease of the respiratory system.

B. Epidemiological Studies of the Effects of Air Pollution on Children in General

The effect of chronic low level exposure to ambient air pollution is a major national concern. We are not certain what the outcome of such exposure may be on the general population and we become alarmed when we read such numbers as 75 to 90% of all lung cancers may be caused by an environmental agent (12).

One group that is widely studied, particularly in Europe and Japan, is that of children. There are many advantages to studying infants and young children. First, the respiratory system of children may be much more sensitive and vulnerable to the air/contaminants in the environment. Secondly, cigarette smoking and occupational exposure have not yet become factors in potential exposure. Finally, they spend most of their early lives at home or in school in a limited geographic area where air quality and meteorology can be measured.

In addition to being excellent subjects to study the effects of air pollution on health, children are also probably the group of most concern. Any potential degradation of health in children due to ambient air pollution is an immense concern because:

1. Adverse effects may not be clinically or physiologically recognizable for many years. Young bodies are very resilient.
2. Some aspects of growth and development may be affected by certain substances found in the ambient air.

Below are briefly summarized the results of a number of studies done on the effects of chronic air pollution exposure on children (5, 12, 23, 41, 50):

1. An English study on children found that lower respiratory infections are definitely related to air pollution. Moreover, the frequency and severity of lower respiratory infections increased as air pollution levels increased.

2. In Japan, one study reported there was a decrease in the peak expiratory flow rate in children during times of increased air pollution.

3. Another English study of school children of the ages 10 to 12 demonstrated differences in ventilatory function on prevalence of respiratory symptoms between students in high versus low air pollution areas.

4. Studies in Eastern European counties have demonstrated the effects of heavy air pollution exposures on growth.

5. A Scottish study of children indicated a relationship between respiratory tract mucous membrane irritation and chronic bronchitis in later life.

6. An Italian study reported a partial correlation between respiratory disease incidence and variations in ambient air pollution, but climatic factors appeared to be of greater influence than air pollution factors.

7. Studies of ventilatory function among school children were performed in Cincinnati, Chattanooga and New York in the United States, England, Japan, Italy, and Canada. A consistent relationship between particulate plus sulfur oxides exposure and impaired ventilatory function exists.

8. The Committee on Environmental Hazards of the American Academy of Pediatrics reviewed the available literature concerning the health effects of specific air pollutants on children. More than 100 studies from numerous countries were evaluated. Numerous individual pollutants have been associated with some type of health defect; these include such pollutants as fluorine, lead, asbestos, silicates, sulfur oxides, total suspended particulates, nitrates, and others. The consistent finding of a relationship between impaired ventilatory function and exposure to air pollutants was documented in the literature. Some specific pollutants also indicated other chemical findings. The association between asthmatic reactions and air pollution also implicate elevated contaminant air levels. Moreover, after reviewing these studies, the American Academy of Pediatrics stated, "These studies also suggest that early exposure to elevated

air pollution levels for periods of more than 5 years was accompanied by a prolonged deficiency of ventilatory capacity."

9. Studies in England, Japan and Russia have implicated ambient sulfur dioxide and particulate matter as causes of increased respiratory morbidity in children.
10. In New York and Chicago, an increase in acute respiratory disease was associated with exposure to sulfur dioxide and suspended particulates. Morbidity was found both among parents and their children.

As can be seen from the brief, general summaries of a number of epidemiological studies on the effects of air pollution on the health of children, there is a definite association. This relationship becomes even more significant when scientists, researchers and health professionals make conclusive statements regarding the effects of air pollution on child health. Respiratory tract illnesses are the most common cause of disease in the United States and account for 50 to 80 percent of all childhood diseases. Moreover, repeated lower respiratory tract illnesses in childhood may contribute to the development of chronic respiratory tract disease in adulthood. Additionally, some aspects of child growth and development may be affected by particular air pollutants.

C. Epidemiological Studies of Adult Populations

A very large number of epidemiological studies, particularly in occupational settings, have been done on adults exposed to specific air pollutants. These studies are difficult to relate to those of ambient environment exposure versus public health for several reasons:

1. Occupational exposure may be very specific (one or several contaminants), while ambient exposure may be to a multitude of pollutants.
2. Additionally, with the exception of limited or intermittent overtime, most individuals are employed for a 40-hour work week. With a recovery period between exposure. Public exposure to ambient pollution may be 24 hours per day, day in and day out or at least for an extended period of time.

3. Another factor is the population being exposed. A workforce would generally include healthy individuals between 18 and 65 years of age. A general population includes the newborne, infirmed, and aged. Additionally, those with pre-existing illness, allergies, and debilatory conditions would be part of the general population.

4. A definite relationship exists between environmental conditions and air pollution. Certain weather conditions enhance the ambient pollution situation while in most work environments, weather is not a factor.

5. The level of exposure is also important to consider. Occupational exposures in general would be greater than ambient pollutant levels, for a given contaminant. However, the amount of exposure with respect to time and scheduled relief periods make it impossible to compare occupational exposure levels to ambient exposure levels for the general public. Allowable occupational exposure limits are not applicable to ambient general population exposure.

6. Finally, variables such as smoking habits, occupational and recreational exposures, age, sex, socioeconomics and other variables are difficult to control in studies on the effect of ambient air pollution on the health of adults in general.

However, several general statements can be made with respect to adult health and ambient air pollution. Increasing air pollution levels have been correlated with decreased pulmonary function and increases in coughing, wheezing and shortness of breath. A local study of adult individuals within Missoula with chronic obstructive pulmonary disease documented such health effects (33b). Additionally, studies of army recruits from urban versus rural areas (3) and adults in urban versus rural areas collaborate the findings of increased respiratory illness among the inhabitants of the urban areas where higher levels of air pollution generally exist.

Another general statement of facts is that it has become widely believed that a large percentage of human cancer in the United States is caused by environmental factors, such as air pollution, water pollution and radiation. Figures as high as 75 to 90% are generated by some investigators. Urban areas have been associated with particularly elevated cancer incidence rates (12).

In the previous section (B. Epidemiological Studies on the Effects of Air Pollution on Children in General), the advantages for studying child populations when determining the effects of air pollution on health were discussed. Many variable factors may be eliminated or controlled in studies of child populations; however, the results of such studies are applicable to the entire population in general. So while studies of the adult population outside of the occupational setting are limited, the results of these and the other children studies are relevant to public health in general.

V. TOXICOLOGY OF CONSTITUENTS IN DUST FROM MINING OPERATIONS

At least ten metals, or compounds of these metals, can be considered carcinogenic:

1. Arsenic
2. Cadmium
3. Chromium
4. Nickel
5. Beryllium
6. Cobalt
7. Iron
8. Lead
9. Titanium
10. Zinc

Cadmium, chromium, and nickel have induced cancer in animals and have been implicated as human carcinogens. Arsenic is also considered a human carcinogen but has not caused cancer in animal species to date. The other six metals have induced cancer in animals but there is no evidence of human carcinogenicity at this time. The toxicology of arsenic, bismuth, copper, cadmium, chromium, iron, lead, manganese, nickel, free silica, and zinc are discussed in the following sections.

A. Arsenic

Arsenic compounds may be absorbed into the human body after ingestion, inhalation and through the skin. Trivalent arsenic compounds are generally the more toxic forms. Symptoms of chronic exposure to arsenic compounds are found primarily in the skin, mucous membranes, gastrointestinal and central nervous systems. Arsenic is retained and stored in all body tissues, the bones and hair. Analysis of arsenic in urine and hair may be used to evaluate exposure.

Dermatitis of the face and eyelids may be accompanied by conjunctivitis, and irritation of the nose, pharynx and bronchial passages may occur. Occupational exposure can result in gastrointestinal disturbances, peripheral neuritis and hematologic changes. The latter is very uncommon and disappears with the

cessation of arsenic exposure. Also, hematologic changes are normally associated with ingestion exposure.

Arsenic compounds may require what is called a promoter to elicit the carcinogenic response. Such promoters would include exposure to respiratory irritants such as SO_2, metal fumes or smoking cigarettes; the irritant facilitates the development of cancer. Arsenic compounds vary in their ability to initiate cancer in humans and most epidemiologic studies indicate arsenic compounds, although they are human carcinogens, have low potency and long latent periods before disease development. In the occupational setting, arsenic has caused both lung and skin cancers and is suspected in cancers of the lymphatic tissue (10, 29, 42, 56).

B. Bismuth

Bismuth compounds may be ingested as a powder or inhaled as a dust. Although bismuth poisonings have occurred with soluble bismuth pharmaceuticals, no cases of industrial poisonings have been documented. The liver and kidney are affected in toxic acute poisonings. However, chronic and/or parenteral exposure can cause the blue-black bismuth line on the gums, foul breath and inflammation in the mouth. Eventually, long-term pharmaceutical exposure could result in nephritis and liver damage. No effects from occupational or ambient exposure to bismuth compounds has been documented (42, 56).

C. Cadmium

Cadmium exposure is primarily via the inhalation of dust and fumes. Ingestion of cadmium compounds is possible, but they are poorly absorbed from the intestinal tract. Regardless of route, once cadmium is absorbed by the human system, it is retained in the kidneys and liver and has a very long half life.

In the industrial setting, acute exposure to cadmium fumes or dust can produce what is known as metal fume fever. Several hours after exposure, the victim experiences upper respiratory tract irritation, followed by cough, chest pains, sweating, and the chills. Within 24 hours, severe respiratory irritation, shortness of breath, cough, and general weakness may follow. Such exposure may be fatal, and for those who survive, recovery may be prolonged. Such exposure is almost always occupational in nature. Chronic cadmium poisoning results from long-term exposure to low levels of cadmium oxide fumes, cadmium oxide dust, cadmium sulfides, and cadmium stearates. Such exposure may affect only the respiratory system, but systemic effects have also been noted after cadmium is absorbed into the body. Coughing, chronic bronchitis and a form of emphysema may result from respiratory system damage, while system changes may include kidney damage and mild hypochronic anemia. Epidemiologic studies have indicated that heavy cigarette smoking may increase tissue cadmium levels and thus may increase the risk of cumulative toxic effects. Cadmium has also been implicated in the development of lung and prostrate carcinomas (21, 42, 54, 56).

D. Chromium

Chromium exists in several valence states. These valences are 2+, 3+ and 6+ and each has different toxicologic potential. The hexavalent and trivalent are biologically significant. Hexavalent forms of chromium compounds convert to the trivalent state within the body. Chromic oxide and chromic sulfate are important trivalent forms, while chromic acid, chromates and dichromates are the most important industrial hexavalents and the most toxic.

Chromium may enter the body by percutaneous absorption, inhalation and ingestion. Chronic exposure to chromium may result in dermatitis, skin ulcerations,

perforation of the nasal septum, inflammation of the respiratory system, and liver damage.

Many chromate compounds are oxidizing agents and thus irritate exposed tissues. Consequently, dermatitis, ulcerations and respiratory irritation are the principal effects. Dermatitis results both from direct contact and from sensitization to chromium. Thus, dermatitis may be an allergenic response.

The ulceration or lesion of greatest concern in chromium exposure is the bronchogenic carcinoma. Excessive respiratory cancer has been found in occupational groups and the inhalation of chromium compounds has been associated with this increased incidence rate. Chromium compounds have been found to cause cancers in the larynx, lung and nasal cavity. The hexavalent compounds have been implicated but there is no conclusive evidence as to which chromium compound or compounds do or do not induce cancer (10, 21, 42, 54, 56).

E. Copper

Copper is an essential dietary element and is widely distributed in nature. Most copper intake is excreted in the feces, but very small amounts of copper ion are absorbed by the body and stored in the liver, blood and brain. A fine balance of copper in the human body is maintained by the intestines and the liver. The intestines act as a barrier to copper absorption and are the organs of excretion, while the liver is the primary storage site.

Locally, copper salts are capable of causing skin and eye irritation. Itching, erythema and dermatitis may result from skin contact. Conjunctivitis of the eye and ulceration and turbidity of the cornea may occur.

Systemically, inhalation of copper dust or fumes may cause upper respiratory tract irritation, a metallic taste in the mouth, nausea, vomiting, metal fume fever, and possibly skin and hair discoloration. In addition to respiratory

tract irritation, copper salts have caused perforation of the nasal system in occupational exposures.

Individuals who suffer from Wilson's genetic disease (hepatolenticular degeneration) may be susceptible to chronic copper exposure. With this condition there is abnormal absorption, retention and storage of copper by the body. If left untreated, the disease is progressive and fatal (10, 21, 56).

F. Iron

Iron is also an essential dietary element and it is necessary for the formation of hemoglobin in the blood. It is a very abundant and widely used element.

Soluble iron salts are skin irritants and aerosols of the salts ferric chloride and ferric sulfate are respiratory tract irritants. Chronic long-term inhalation of iron oxide fumes or dust may produce a benign pneumoconiosis called siderosis. This disease causes a mottling of the lungs; and if other dusts, particularly free silica, are present, fibrotic pulmonary changes occur. The presence of iron and free silica simultaneously in the ambient environment may have serious implications on public health. Whether iron plus other dusts act additively or synergistically with each other is not clear, but the presence of other dust in addition to iron induces more significant lung changes.

Animal studies have implicated iron as a potential human carcinogen. Cancers have been experimentally induced in hamsters, mice, rats, and rabbits via intramuscular, intraperitoneal and subcutaneous exposure to iron carbohydrates (10, 21, 54, 56).

G. Lead

There are two routes of entry into the human body for lead: (1) through inhalation of vapor, fume, dust, or mist into the respiratory tract; and (2) by

swallowing lead trapped in the upper respiratory tract or by introducing lead into the gastrointestinal tract via food, tobacco, or other substances. It is estimated that approximately 37 percent of the lead inhaled is retained in the lungs to be absorbed into the body, while 85-92 percent of the lead swallowed passes through the body unabsorbed only to be excreted. Once absorbed, lead tends to accumulate in the bones. More than 90 percent of the body burden may be found in the skeleton, with other areas of concentration in the aorta, liver, kidney, pancreas, lungs, spleen, testes, heart, and brain.

Lead is excreted both in the urine and feces. If there is an equilibrium between the intake of lead and its excretion, there will be no accumulation of lead in the body.

The metabolism of lead is very similar to that of calcium, especially with regard to its deposition and mobilization from bone. When bone marrow activity is increased, such as with leukemia or anemia, lead may be liberated back into the blood. Thus, an individual who may no longer be exposed to lead industrially can be re-exposed years later when previously tied-up lead is released back into the system.

The earliest symptoms of lead poisoning are fatigue, disturbance of sleep, constipation, a slight weakness of the upper extremities, wrists and fingers, and colic.

Lead poisoning may affect the central nervous, gastrointestinal, hematologic and renal systems of the human body. Symptoms of effects on the central nervous system may include encephalopathy, fatigue, headaches, tremor, hallucinations, and intellectual deterioration. Colic, loss of appetite, nausea, vomiting, and constipation may result from effects to the gastrointestinal tract. Effects of lead poisoning on the hematologic system include anemia, basophilic stippling erythroblasts, binucleated erythroblasts and increased

serum iron, while hyperuricemia, nephritis, glycosuria and hyperaminoaciduria may indicate renal damage.

Continued exposure to lead may lead to the more serious effects and permanent damage. Various parameters may be used to diagnose lead poisoning. Blood sampling and analysis for lead and zinc protoporphyrin are common biological parameters used to evaluate the body burden from lead exposure.

Lead has been associated with an increased cancer risk in occupational exposures. It is a suspected kidney and lung carcinogen. Additionally, lead has induced cancer in experimental animals. Moreover, lead has been found capable of crossing the placental barrier between a pregnant mother and her fetus and is a suspected teratogen. Teratogens are agents that are capable of causing malformations or abnormalities in developing fetuses. Some teratogens apparently are directly toxic to fetuses, while other agents probably interfere with fetal metabolism. The precise mechanism of lead is not known at this time (10, 14, 21, 42, 56).

H. Manganese

Manganese is primarily absorbed into the body through the respiratory tract; absorption through the skin or gastrointestinal tract is not significant. Once absorbed, manganese tends to accumulate in the liver, kidneys, pancreas, and brain. Destruction of the ganglion cells of the basal ganglia and degeneration around vascular areas of the brain are characteristic of manganese poisoning. Also, liver cirrhosis may develop. Excretion of manganese takes place almost exclusively by the feces. Very little is excreted in the urine.

The effects of chronic low-level exposure to manganese have been recognized and documented for more than 100 years. Since the primary hazards of manganese are from chronic exposure, not much data is available on acute poisonings. The

first symptoms of chronic exposure include apathy, loss of appetite and lack or loss of strength. The manganese psychosis that follows includes unaccountable laughter, euphoria, irritability, impulsiveness, and insomnia followed by drowsiness, headaches, a tendency to cry, recurring leg cramps, speech disturbances, incoherence, mental confusion, clumsiness, and compulsive behavior such as singing, running or fighting. If exposure and the conditions persist, a masklike face, altered gait and a Parkinson-like syndrome may develop.

Although the process is usually slow, victims of chronic manganese exposure may partially recover when removed from the exposure and with proper treatment. Individual susceptibility appears to be significant in manganese exposure. Factors such as alcoholism, chronic infections and liver dysfunction may influence individual sensitivity.

Respiratory disease has also been shown to have an increase incidence in individuals exposed to manganese dust. Metal fume fever or manganese pneumonitis is an acute reaction to manganese exposure, usually following exposure to high levels. Fever, chills, labored breathing, and cough are symptomatic of the fume fever (10, 21, 42, 56).

I. Nickel

Nickel compounds enter the body by inhalation of dust or fumes. As a local effect, nickel eczema is common. Also, skin sensitization is a prevalent toxic reaction to nickel. Additionally, irritation of the eye's conjunctiva and upper respiratory tract's mucous membrane may be noted.

Elemental nickel and nickel salts are probably carcinogenic; cancers of the lung and nasal passages of occupational groups have been associated with nickel for many years (10, 21, 42, 54, 56).

J. Free Silica

Free silica or silicon dioxide is abundant in the earth and exists in several forms. However, only the crystalline forms produce the chronic debilitating pulmonary condition known as silicosis. Quartz is the most common form of free silica. Crystobolite and tridymite are less common forms of free silica.

Initially, lesions called silicatic nodules may result from exposure to free silica. Early on, the nodules occur in or adjacent to the walls of the respiratory bronchioles. As the disease progresses, fibrosis spreads. Eventually, what appears to be a continuous mass of fibrous tissue develops. Shortness of breath, decreased chest expansion, absence of fever, decreased ability to work, and a susceptibility to tuberculosis are some effects of silicosis.

In addition to debilitation of the pulmonary system, free silica acts synergistically with acid-fast bacillary infections and favors the growth of such infections as the tubercle bacilli, thus the high association of tuberculosis with silicosis victims. Also, silicosis may be associated with pulmonary hypertension and/or pulmonale. This may be a consequence of the damage to the walls of blood vessels and mechanical obstruction in the chest due to fibrosis (10, 21, 56).

K. Zinc

Zinc and its compounds are relatively non-toxic if taken by mouth, but the inhalation of zinc oxide fume and zinc oxide dust results in metal fume fever. A number of metals are associated with this condition, but zinc is one of the more frequent causes of this condition and is strongly associated with it. Metal fume fever results from the inhalation of large doses of zinc oxide dust or zinc oxide fumes. It is a delayed form of mild pneumonitis. Typically, within four to eight hours after exposure, the individual develops symptoms of

fever, chills, labored breathing, ache, nausea, dry throat, and cough. Usually within a few hours, all of the symptoms disappear without any specific treatment.

It is questionable whether low-level chronic exposure to zinc will result in adverse effects. In documented environments where zinc has been suspected as the causative agent, it is now considered that other potentially harmful substances simultaneously present, such as arsenic, antimony, hydrogen sulfide and ammonia, may have been responsible for the symptoms and adverse effects. However, zinc compounds have been implicated as potential human carcinogens because they have induced cancers in experimental animals.

L. Individual Susceptibility

The severity and extent of symptoms resulting from exposure to hazardous substances are related to many factors including such parameters as duration of exposure, airborne concentration, rate of respiration, particle size, route of entry, rate of elimination or storage, and so on. One other factor to consider is individual sensitivity or susceptibility. Everyone does not necessarily react in the same way at a given exposure level of concentration. Some persons are more tolerable; others are more sensitive or intolerable of the insult.

Depending on whether one is talking about a substance that affects the blood, kidneys, liver, central nervous system, respiratory system, skin or any other tissue or organ of the body, any pre-existing disease or condition may cause an individual to be more susceptible to the effects of exposure to a particular compound. Additionally, age, sex, physical condition, previous exposure, and hereditary factors may influence individual susceptibility. The very young, very old and those with pre-existing conditions are the most susceptible groups.

One point that has been mentioned previously but is significant enough to discuss one additional time is the fact that there may be no relief from ambient environmental exposures. The contaminants may be present 24 hours per day, day in and day out or for very extended periods of time. There is no recovery period between exposures as in an occupational setting where one is exposed for approximately 40 hours per week. Toxicologically, this may be very significant, particularly with pollutant contaminants that accumulate and store in the body.

M. Potential Additive or Synergistic Effects of Harmful Air Pollutants

When two or more potentially hazardous materials are present in a work setting, their combined effect on employees is considered instead of that of either one of them individually. In other words, their effects are considered additive. The exception to this would be if it is known that the primary effects of the harmful substances are on different organs of the body (for example, if one substance was known to affect the kidneys while another affects the respiratory system).

In ambient environmental exposure, this should also be taken into account when determining the potential hazard of a pollution situation. For example, four of the metals discussed affect the following primary organs or systems:

Lead: Central Nervous System
Gastrointestinal Tract
Hematologic (Blood)
Renal (Kidneys)

Manganese: Central Nervous System
Liver

Zinc: Respiratory System

Arsenic: Skin
Mucous Membranes
Gastrointestinal Tract
Central Nervous System
Respiratory System

Lead, manganese and arsenic all involve toxicologic action on the central nervous system, while zinc and arsenic act on the respiratory system and lead and arsenic on the gastrointestinal tract. This factor of additiveness is significant when evaluating the total potential health hazard from ambient air pollution.

Another example of an additive or possibly a synergistic relationship is between iron and silica. The pneumoconiosis caused by exposure to iron dust, siderosis, is a benign condition. However, if other dusts, particularly free silica, are present, fibrotic pulmonary changes occur. The presence of free silica in addition to iron induces more significant lung changes.

Synergism is another toxicologic reaction that has been briefly mentioned in previous discussions. Certain gases or particulates present and acting together are capable of producing a far greater effect or reaction than the separate individual contaminants. Even if one were to add up the individual contaminant effects, the sum would not approach to the severe reaction they produce together. The presence of certain pollutants in combination with others enhances their toxicologic potential. The potential for synergism in an ambient environmental exposure may be very real and significant. At any given time, a number of pollutants may be present and the relationships and interaction of these contaminants is not well defined at this time. Data to date does indicate that the combination of contaminants present in the ambient environment, the meteorological conditions and the interaction between these factors is a very complex relationship, one that has not been defined at this time. Moreover, the effects of individual contaminants at very low-level chronic exposures has not been distinctly specified. Thus, the potential for synergistic reactions is very real and our knowledge of such effects is limited.

VI. SAMPLING AND ANALYTICAL RESULTS FOR AIRBORNE PARTICULATES, STREET DUST AND MINE DUMP MATERIAL

In 1978, a portion of Butte was designated as a non-compliance area. Considerable air quality data has been developed in Butte by the Montana Air Quality Bureau, The Anaconda Minerals Company, MERDI/MultiTech, and others. The use of unwashed sand on streets in the Butte area and off-road traffic in peripheral areas contribute to air pollution in Butte. The Clark Tailings and Colorado Tailings have been identified as occasional sources of dust due to high winds. Some waste dump areas are also sources of dust in ambient air. There has, however, been little study of waste dumps in the Butte area as a source of airborne particulates.

A. Montana Air Quality Bureau

1. Butte Emissions Inventory

A number of reports have been issued under the auspices of the Montana Department of Health and Environmental Science, Air Quality Bureau (AQB). In recent years, various estimates of particulate emissions have been reported by various investigators. Table 2 summarizes the history of estimated particulate emissions for the Butte area from 1970 to 1981. Two obvious conclusions can be drawn from the data.

a. The emissions estimated in the 1970-73 period were unrealistically low.

b. Since 1975, the estimated total particulate emissions from all sources have decreased significantly.

Fugitive dust from The Anaconda Minerals Company mining operations (now suspended) and the community's paved and unpaved roads and streets were major contributors to the total suspended particulate (TSP) problem in Butte. Furthermore, dirt washed onto the Butte streets from inactive mine areas is the major source of street dust in urban areas encompassing or adjacent to the abandoned

mine lands (65). The breakdown of estimated emissions for 1981 are shown in Table 3.

TABLE 2. ESTIMATED PARTICULATE EMISSIONS HISTORY FOR THE BUTTE AREA

Year	Estimated Anaconda Co. Emissions (tpy)*	Estimated City of Butte Emissions (tpy)*	Total Emissions (tpy)*
1970	N.R.	N.R.	3,670 (24)
1971	6,000 (15)	N.R.	N.R.
1972	6,000 (15)	N.R.	N.R.
1973	6,000 (15)	N.R.	N.R.
1975	49,165	17,709	66,874 (62)
1976	6,000 (16)	N.R.	N.R.
	41,050	17,336	58,386 (62)
1977	30,853	13,278	44,131 (62)
1978	32,347	11,474	43,821 (62)
1979	39,029	11,186	50,215 (62)
1980	15,000	11,000	26,000 (33h)
	5,144 (49)	N.R.	N.R.
	13,044	10,432	23,476 (62)
1981	20,297	11,564	31,861 (62)

* Includes Point Source and Fugitive Dust Emissions.

The 1983 Montana State Implementation Plan for the Butte non-attainment area recommended a control stragegy that included a maximum of 25,400 tons per year of particulates emitted to the atmosphere (24).

The sources of the increased dust on the city streets have been (1) airborne particulate matter from the Berkeley Pit (now suspended), some of which settles out over the city and (2) precipitation events that result in the washing of soil or carry-on of soil by vehicles from barren or unpaved areas to the traffic lanes. Much of this particulate matter can become involved in a cycle of entrainment in air, settling out and re-entrainment in air, repeating itself over and over. The principal way of breaking this closed-loop cycle of airborne particulate is to vacuum or wash the dirt from the city streets or to prevent the soil from reaching the streets.

Table 3 does not include a separate distribution of the sources of particulate emissions from the paved and unpaved streets and roads. The following questions have to be asked. What are the sources of the dust that accumulate on the paved streets? What portion of this dust comes from the surface of abandoned mine land areas:

TABLE 3. ESTIMATE OF TSP EMISSIONS FOR THE BUTTE AREA - 1981 (24)

Estimated Anaconda Company Emissions - 1981	
Activity	Emissions (tons/year)
Drilling	19
Blasting	43
Shovel Loadout	629
Dragline Loadout	10
Haul Trucks	9,622
Dumping	1,040
Backfilling	3,780
Active Storage	3,360
Wind Erosion	201
Blade Vehicles	944
Support Vehicles	557
Diesel Exhaust	92
TOTAL	20,297

Estimated City of Butte Emissions - 1981	
Activity	Emissions (tons/year)
Paved and Unpaved Roads	11,048
Fireplaces	140
Construction	30
Aggregate Storage	1
Railroad Yards	10
Heating Fuel Combustion	50
Highways	194
Riteway Asphalt Co.	60
Gilman Construction Co.	6
Montana Pole	20
Silver Bow Asphalt Plant	5
TOTAL	11,564

The final report of the Montana Air Pollution Study (33h, 1981) included the estimates of annual emissions of minor air pollutants for Butte (Table 4). The report does not discuss the chemical form of these metals. If the minor pollutants become airborne throughout a period of one year, averaging 10 $\mu g/m^3$ of air, the total mass (2724 tons) would be sufficient to contaminate about 2.3×10^{14} m^3 of air (or 58,000 cubic miles of air).

TABLE 4. ANNUAL EMISSION ESTIMATES FOR MINOR POLLUTANTS (33h)

Pollutant	Estimated Berkeley Pit Emissions (tpy)	Estimated City of Butte Emissions (tpy)
Lead	9.1	6.8
Arsenic	1.4	0.32
Cadmium	0.32	0.06
Vanadium	2.3	2.0
Copper	57	9.7
Iron	410	200
Aluminum	1,000	940
Zinc	44	13
H_2SO_4	0	28

2. Butte Airborne Particulate Sampling

The Federal and Montana ambient air quality standards for total suspended particulates, hydrocarbons and lead which are included in this abandoned mine land study are shown in Table 5.

Since 1971, the Air Quality Bureau of the Montana DHES has installed and operated ambient air sampling equipment at a number of locations for various lengths of time in Butte. The high-volume sampler locations in the general area encompassed by this Abandoned Mine Land Study include:

a. Butte Courthouse

b. Webster-Garfield School

c. Atkins Residence, Walkerville

d. Richer Residence, Southeast of Bert Mooney Airport

e. Hebgen Park

f. Dr. Canty's Office

g. Blaine School, Walkerville

Appendix 1 includes the locations of these air sampling sites. The results of eleven years of sampling for total suspended particulates on an annual basis at these selected sites are summarized in Table 6. The annual background suspended particulate level for the Butte area appears to be about 20 $\mu g/m^3$ (Richer Residence). The particulate level for Walkerville ranges from 22 to 45 $\mu g/m^3$. The suspended particulate level at sampling stations in the uptown area of the abaondoned mine land study ranged from 48 to 77 $\mu g/m^3$ (excluding 1971 values).

TABLE 5. FEDERAL AND MONTANA AMBIENT AIR QUALITY STANDARDS

National Ambient Air Quality Standards

Pollutant	Primary Standard	Secondary Standard
1. Total Suspended Particulate Matter	75 $\mu g/m^3$/ annual geometric mean, 260 $\mu g/m^3$, 24-hour average*	60 $\mu g/m^3$ annual geometric mean, 150 $\mu g/m^3$, 24-hour average
2. Lead	1.50 $\mu g/m^3$, quarterly	----
3. Non-Methane Hydrocarbons	160 $\mu g/m^3$, 0.24 ppm, 6-9 A.M. average*	----

Montana Ambient Air Quality Standards

Pollutant	Standard
1. Total Suspended Particulate Matter	200 $\mu g/m^3$, 24-hour* 75 $\mu g/m^3$, annual
2. Lead	1.5 $\mu g/m^3$, 90 day**

*Not to be exceeded more than once a year.
**Not to be exceeded.

A Montana Air Quality Bureau study (6) of airborne particle size at the old Harrison School (near the Berkeley Pit) showed that mass mean diameter (MMD) was 7.0 microns. This means that 50 percent of the mass of airborne

TABLE 6. ANNUAL AVERAGE TOTAL SUSPENDED PARTICULATES FROM SAMPLING STATIONS RELATED TO ABANDONED MINE LAND STUDY

Total Suspended Particulate from High-Volume Samplers (μg/M^3)

Sampler Location	1971*	1972	1973*	1974*	1975*	1976*	1977*	1978*	1979*	1980*	1981*
1. Courthouse	74										
2. Webster-Garfield School	84										
3. Atkins Residence, Walkerville			32	22.7 (6) 40 (44)	43.4 (16)	45 (44) 46.3 (17)	30.5 (18)				
4. Richer Residence, SE of Bert Mooney Airport					17.7 (16)	18 (44) 17.8 (17)	19.4 (18)				
5. Hebgen Park								59 (62)	77 (62)	77 (62) 74 (56) 74 (47)	65 (49)
6. Dr. Canty's Ofice								48 (62)	62 (62) 61 (56)	66 (62)	49 (49)
7. Blaine School, Walkerville										28 (56)	30 (49)

*Geometric mean.

particulate was seven microns or smaller in size. The relationship between particle size and the effected area of the human respiratory system (6) is shown as follows:

Particle Size (microns)	Area Reached and Affected
7.0 and above	Nasopharnyx Area
3.3 - 7.0	Trachea and Primary Bronchi
2.0 - 3.3	Secondary Bronchi
1.1 - 2.0	Terminal Bronchi
Submicron	Alveoli (CO_2 and O_2 Transfer Area)

Respirable particulate was sampled as part of the MAPS program (56). The respirable particulate was collected by dichotomous samplers. The samplers split the respirable particulates (15 microns and less) into coarse (2.5 to 15 microns) and fine (less than 2.5 microns) fractions. The respirable particulate factions at the Hebgen Park sampling station are listed below.

Size Classification of Respirable Particulates ($\mu g/m^3$)

		<2.5		2.5-15		<15	
Site	Year	Max	Mean	Max	Mean	Max	Mean
Hebgen Park	1979*	56.1	17.9	82.9	34.7	112.3	52.6
	1980*	69.5	21.6	102.1	30.2	140.4	49.4

*Eight sample months in both years.

The fine fraction (less than 2.5 microns) contributed 34 to 44 percent of the total respirable particulates (less than 15 microns).

3. Trace Element Analysis

A study of the air pollution in seven Montana cities (1) in 1961-62 reported on the lead and arsenic fractions in suspended particulate in the ambient air of the communities. The results are as follows:

	Years Average Concentration ($\mu g/m^3$)	
	Arsenic	Lead
Butte	0.07	0.41
All Other Cities	0.08	0.39

The year's lead average for Butte was slightly above the all-cities average. The year's arsenic average for Butte would have been above the all-cities average if Anaconda were excluded from the calculation.

Additional trace element analysis of suspended particulates collected on the filters of high-volume samplers were conducted during two later periods (1971-72 and 1979-80) by the Montana Air Quality Bureau (6, 56). The analysis results are summarized in Table 7.

TABLE 7. TRACE ELEMENT ANALYSIS OF TOTAL SUSPENDED PARTICULATES FROM SAMPLING STATIONS RELATED TO ABANDONED MINE LAND STUDY ($\mu g/m^3$)

Sample Site	Sampling Period	As	Pb	Cd	Zn	SO_4	NO_3
Courthouse (6)	2/71-3/72	0.13	0.51	0.04	0.35	N.R.	N.R.
Webster Garfield School (6)	2/71-3/72	0.15	0.79	0.02	0.35	N.R.	N.R.
Hebgen Park (56)	1979 1980	0.014 0.017	0.28 0.26	0.006 0.010	N.R. N.R.	5.2 5.9	2.5 2.2
Dr. Canty's Office (56)	1979 1980	0.018 0.024	0.29 0.29	0.007 0.011	N.R. N.R.	5.2 6.2	2.0 2.5

B. MERDI/MultiTech

The Montana Energy and MHD Research and Development Institute (MERDI) was contracted by the Department of Energy (DOE) in 1975 to design and implement an air quality/meteorological monitoring network. The monitoring and evaluation

program would verify the Component Development and Integration Facility (CDIF) impact on ambient air quality. Monitoring started in January 1977 and continued through 1979. During 1979, nine sites were available for sampling: one permanent station and eight enclosures serviced by four mobile units (37). All sites were located within the area known as the Butte Summit Valley, which is situated south of Interstate 90/15 and north of the Highland Mountains (Figure 1). Limited monitoring has continued from 1980 to 1983. The data, however, has not been entered into a data base. Printouts of selected data can be provided only after manually entering available data into a data base for data handling.

Since 1978, the Montana Air Quality Bureau has designated the Summit Valley south of Interstate 90/15 as an attainment area for total suspended particulate (TSP). MERDI's data was instrumental and clearly defends this designation for 1977-1979. Table 8 shows that a maximum TSP value of 179 $\mu g/m^3$ was recorded. This would exceed the 24-hour National Secondary Standard for TSP of 150 $\mu g/m^3$, but was not in violation since the episode occurred only once during 1979. The particulate sample was from MERDI's northernmost station approximately one mile south of Interstate 90/15 (Station No. 7, Figure 1).

Suspended sulfate (SO_4) determined from fiberglass A/E filters is about 2.5 times higher than SO_4 determined from Whatman 41 filters. Artificial formation of SO_4 is suspected by sulfur dioxide reactions with the basic (pH 8-9) fiberglass filters (37).

The Butte Summit Valley is 5,600 feet above MSL and is surrounded by mountains rising from 1,000 feet to 4,500 feet above the valley floor. Because of this bowl-type topography, cold air frequently drains into the valley from the surrounding mountains, resulting in strong daily temperature inversions forming about 82 percent of the nights. All-day inversions occur about 42 percent of the time from November through March and can last up to 75 hours (37).

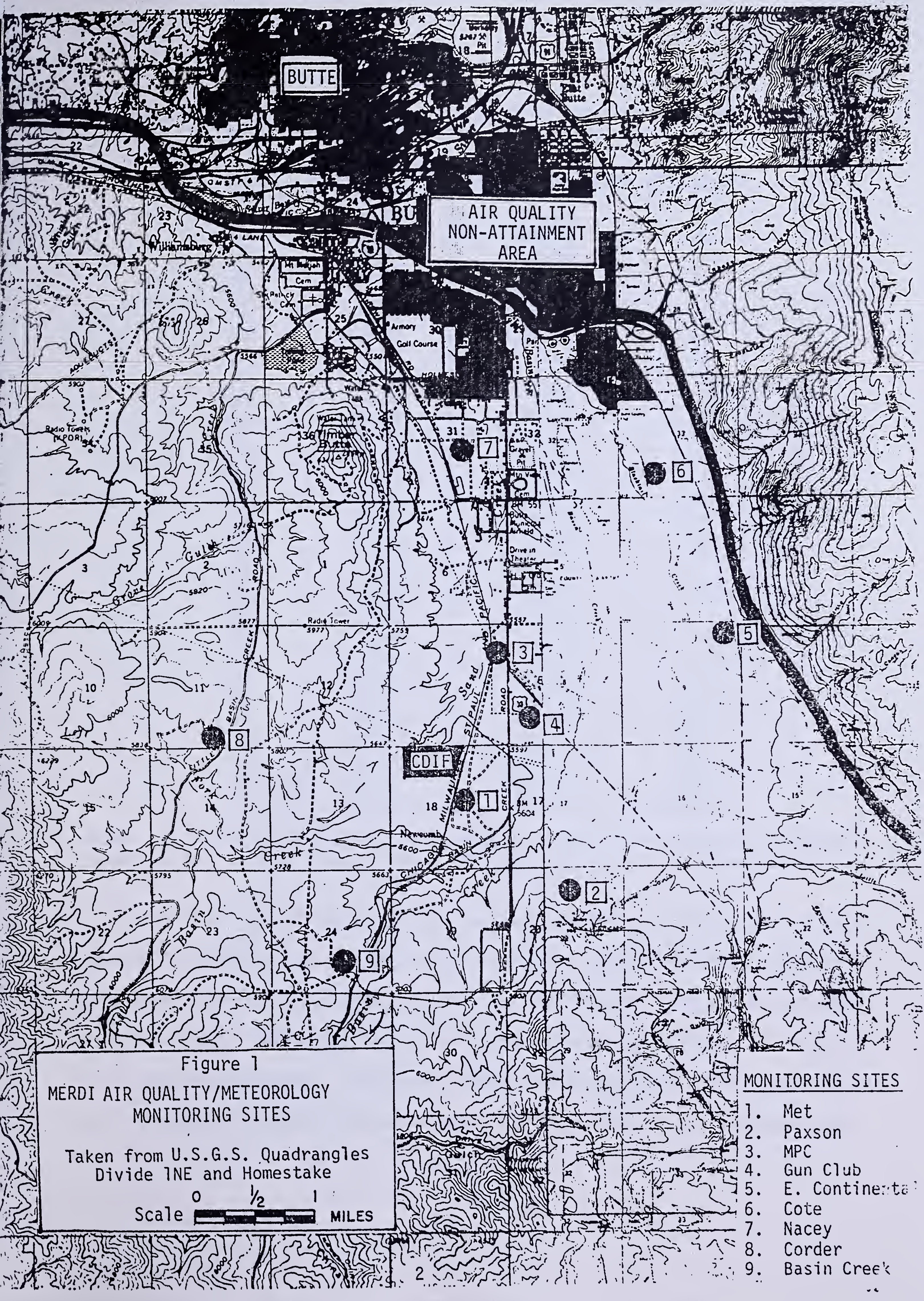


Figure 1

MERDI AIR QUALITY/METEOROLOGY MONITORING SITES

Taken from U.S.G.S. Quadrangles Divide 1NE and Homestake

Scale 0 ½ 1 MILES

MONITORING SITES

1. Met
2. Paxson
3. MPC
4. Gun Club
5. E. Continenta
6. Cote
7. Nacey
8. Corder
9. Basin Creek

TABLE 8. HIGH-VOLUME SAMPLING ALL STATIONS THREE-YEAR AVERAGES SUMMARY*
BUTTE SUMMIT VALLEY, 1977 to 1979 (37)

	Average Mean	Standard Deviation	Max Value
TSP AV	34.11	13.75	179
TSP GM	30.44	12.76	179
AL	581.78	380.45	7,456
AS	16.11	4.04	153
B	49.78	11.07	160
BE	0.33	0.50	7
BI	47.11	18.14	256
CA	709.33	538.27	9,412
CD	4.44	1.42	685
CO	1.33/1.44	2.18/2.19	54
CR	4.89	1.36	28
CU	351.89	54.44	1,580
F	12.00	1.41	113
FE	561.00	300.99	6,551
HG	2.67	1.00	24
K	220.89	143.03	2,557
MG	164.67	109.70	941
MN	18.33	10.50	456
MO	5.22	5.78	231
NI	2.56	1.51	32
PB	50.00	20.41	570
SB	0.78	0.44	5
SE	0.89	0.78	10
SN	2.67	0.87	24
V	3.67/3.78	2.12/2.22	248
ZN	56.33	11.79	657
CL	906.38	443.65	5,455
NO_3	802.22	172.71	5,963
PO_4	290.11/292.67	104.97/101.69	5,541
SO_4 (W)	1719.20	1029.94	7,263
SO_4 (F)	4423.22	697.32	16,160

*Each station weighted equally. TSP values in $\mu g/m^3$ using Fiberglass A/E; all other values in ng/m^3 using Whatman 41. SO_4 Whatman (W); by Fiberglass (F).

Horizontal variations in the airflow exist within the Butte Summit Valley, especially during strong drainage flow conditions. Wind rose data from MERDI's permanent station (CDIF) during December 1977 to February 1979 and wind roses from the airport during the same period show a pronounced difference. Both have a bi-model distribution. The airport winds were predominantly from the northwest and southeast, while the CDIF winds were from the southwest and northwest (64).

Butte Summit Valley air quality does not appear measurably deteriorated by the abandoned mine lands under study.

C. The Anaconda Minerals Company

The Anaconda Minerals Company began monitoring for total suspended particulate (TSP) in the mid-1960's. Both fiberglass A/E and Whatman 41 filter papers were used during the early years. Fiberglass filters gave way to the Whatman filters when heavy metal analysis indicated lower background metals in the Whatman 41 filters. They are, however, humidity sensitive. Fiberglass filters were not employed again by the Anaconda Minerals Company until 1979. High-volume data were analyzed from the Belmont Mine, Lexington Mine, Kaw Avenue, and Butte Operations Shop-Montana Power Company monitoring stations (Appendix 1). Raw data from 1977 to 1983 were reduced and tabulated in Tables 8 to 11.

The air quality in the area of the Belmont Mine station has consistently been in violation of the 24-hour National Secondary Standard and the 24-hour Montana State rule, the worst years being 1979, 1980 and 1981. Violations at this station can be attributed to the following:

1. Close proximity of the station to pit operation.
2. Abandoned dumps near the station.
3. Station is near two main traffic thoroughfares.

The Kaw Avenue station also had episodes exceeding the 24-hour state and federal standards several times in 1980 and 1981. The Montana Power and Lexington Mine stations had no violations for the years studied. Violations have occurred at the Belmont Mine and Kaw Avenue stations generally during December and January to May in the years of maximum loading. This coincides with the increased number of all-day inversions during November to March according to MERDI's meterological data (37). Even though the Anaconda Minerals Company

TABLE 9. HIGH VOLUME SAMPLES - YEARLY AVERAGE SUMMARY, THE ANACONDA MINERALS COMPANY BELMONT MINE STATION VALUES in $\mu g/m^3$

	Whatman 41 Filter		Fiberglass Filter					
Pollutant/Year	1977	1978	1979	1980	1981	1982	1983	Remarks
TSP	61.7	64.0	122.0	85.2	81.9	49.9	48.6	
Benzene Soluble Hydrocarbon	4.0	4.6	--	7.1	3.7	8.20	8.25	
Cu	0.63	0.43	--	0.22	0.38	0.38	0.24	
Pb	0.33	0.34	--	0.16	0.14	0.09	0.09	
Cd	0.010	0.006	--	0.003	0.005	0.004	0.002	
As	0.132	0.053	--	0.005	0.010	0.002	0.003	
Zn	0.26	0.22	--	0.15	0.25	0.12	0.11	
Fe	1.80	1.48	--	--	--	0.91	0.81	
Ca	1.37	1.67	--	--	--	--	--	
SO_4	2.264	2.335	--	--	--	--	--	
MO	--	--	--	--	--	0.028	0.085	
NO Samples	53	15	37	59	56	57	45	
Days Over TSP Standards	2>150 0>200 0>260	0>150 0>200 0>260	10>150 5>200 3>260	8>150* 5>200 2>260	7>150 2>200 0>260	3>150 0>200 0>260	3>150 1>200 0>260	*One day due to Mt. St. Helens. Sample 3 days after 5/18/80 eruption.

TABLE 10. HIGH VOLUME SAMPLES - YEARLY AVERAGE SUMMARY, THE ANACONDA MINERALS COMPANY KAW AVENUE STATION VALUES in $\mu g/m^3$

Pollutant/Year	Whatman 41 Filter		Fiberglass Filter					
	1978	1979	1979*	1980	1981	1982	1983	Remarks
TSP	54.0	59.0	66.4	84.8	103.2	52.3	57.8	
Benzene Soluble Hydrocarbon	4.8	4.2	4.6	9.5	4.4	9.8	9.1	*1979 - 28 samples
Cu	0.33	0.38	0.20	0.25	0.27	0.11	0.10	*1979 - 28 samples
Pb	0.28	0.26	0.37	0.25	0.16	0.13	0.13	*1979 - 28 samples
Cd	0.005	0.008	0.006	0.008	0.005	0.005	0.002	*1979 - 28 samples
As	0.020	0.015	0.015	0.008	0.0050	0.002	0.002	*1979 - 28 samples
Zn	0.14	0.14	0.15	0.14	0.14	0.07	0.10	*1979 - 28 samples
Fe	1.39	1.13	--	--	--	1.40	0.82	*1979 - 28 samples
Ca	1.70	2.72	--	--	--	--	--	*1979 - 14 samples
SO_4	2.298	2.040	5.771**	--	--	--	--	*1979 - 14 samples *Fiberglass produces high SO_4 results.
MO	--	--	--	--	--	0.016	0.042	
No. of Samples	35	42	57	61	56	61	44	
Days Over TSP Standards	0>150 0>200 0>260	0>150 0>200 0>260	1>150 0>200 0>260	8>150 4>200 2>260*	7>150 6>200 6>260	1>150 0>200 0>260	1>150 0>200 0>260	*One day due to Mt. St. Helens. Sample 3 days after 5/18/80 eruption.

TABLE 11. HIGH VOLUME SAMPLES - YEARLY AVERAGE SUMMARY, THE ANACONDA MINERALS COMPANY LEXINGTON MINE STATION VALUES in $\mu g/m^3$

Pollutant/Year	Fiberglass Filter			
	1981	1982	1983	Remarks
TSP	28.7	21.0	26.4	
Benzene Soluble Hydrocarbon	1.08	4.0	5.7	
Cu	0.21	0.18	0.21	
Pb	0.08	0.04	0.04	
Cd	0.004	0.003	0.002	
As	0.005	0.001	0.002	
Zn	0.11	0.05	0.07	
Fe	--	0.55	0.45	
Ca	--	--	--	
SO_4	--	--	--	
MO	--	0.021	0.031	
NO Samples	21	41	40	
Days Over TSP Standards	0>150 0>200 0>260	0>150 0>200 0>260	0>150 0>200 0>260	

TABLE 12. HIGH VOLUME SAMPLES - YEARLY AVERAGE SUMMARY, THE ANACONDA MINERALS COMPANY MONTANA POWER COMPANY STATION VALUES in $\mu g/m^3$

	Whatman 41 Filter			Remarks
Pollutant/Year	1977	1978	1979	Sampler approximately 800 ft above ground.
TSP	50.6	49.7	44.7	
Benzene Soluble Hydrocarbon	3.3	2.6	4.6	1978 - 21 samples
Cu	0.55	0.85	0.38	1978 - 21 samples
Pb	0.45	0.16	0.25	1978 - 21 samples
Cd	0.012	0.005	0.012	1978 - 21 samples
As	0.108	0.012	0.023	1978 - 21 samples
Zn	0.20	0.24	0.17	1978 - 21 samples
Fe	1.71	1.54	1.16	1978 - 4 samples
Ca	2.33	3.15	1.54	1978 - 4 samples
SO_4	1.943	1.450	1.941	1978 - 21 samples
MO	--	--	--	
NO Samples	52	32	50	
Days Over TSP Standards	0>150 0>200 0>260	0>150 0>200 0>260	0>150 0>200 0>260	

discontinued mining and milling operations in June 1983, there is no definite indication that air quality has improved in Butte during the summer of 1983. Continued monitoring will be performed during the suspension of operations to enable an accurate assessment of the impact the shutdown has on the Butte air quality.

The low values of heavy metals in the collected TSP makes it difficult to determine how the metal content varies with the dust loading. Standardizing the TSP and metal loadings and plotting the standardized values (Figure 2) show a definite trend supporting the commonly held assumption that an increase in TSP carries with it an increase in heavy metal content.

Parameter concentrations were standardized using the following relationship:

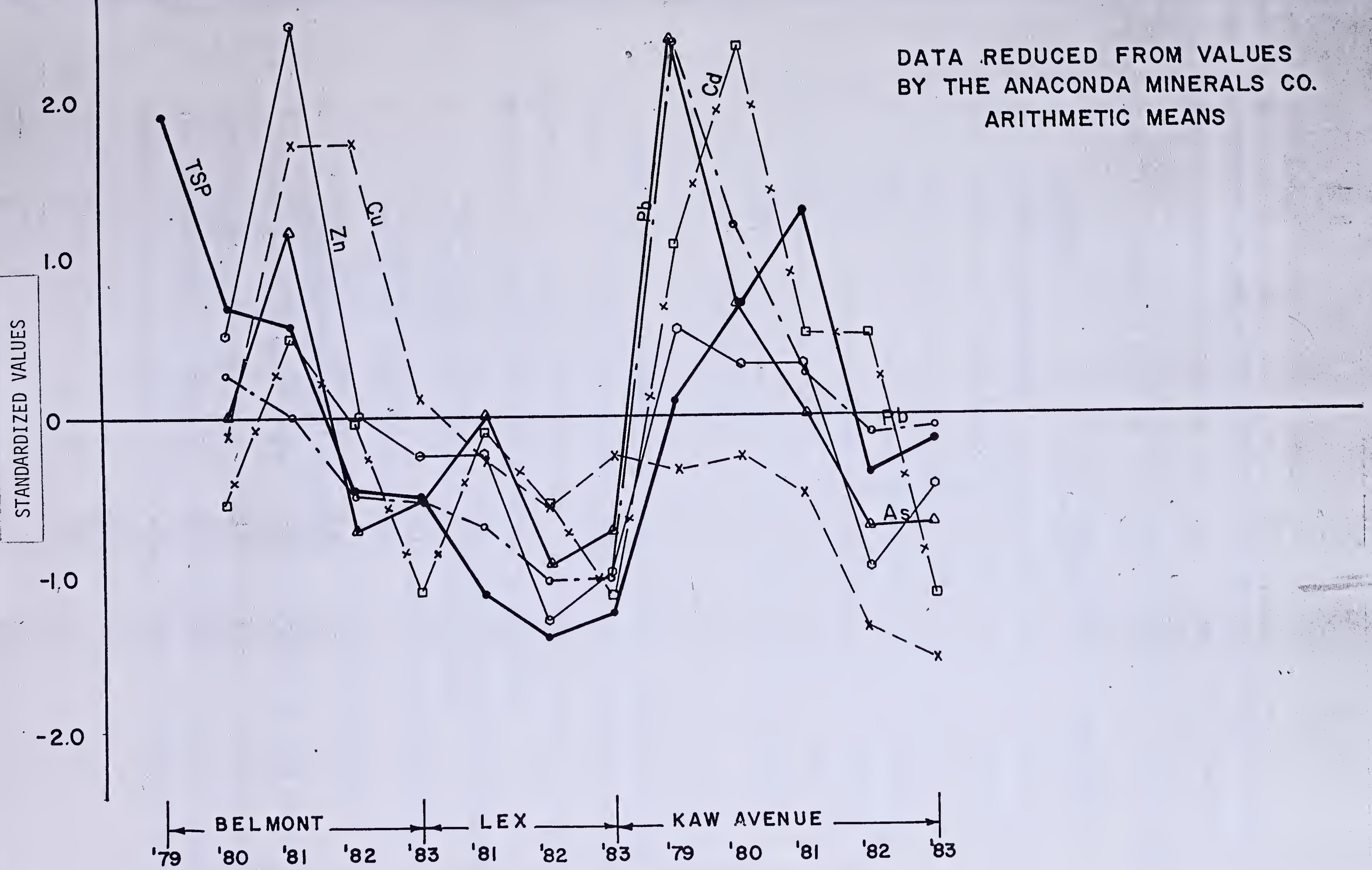
$$X = \frac{U_x - \overline{U}}{SD}$$

where X = Standardized value of selected parameter
U_x = Individual value considered
$\overline{U}$ = True mean of all values considered
SD = True standard deviation of all values considered

Average concentrations of selected constituents tabulated in Tables 8-10, under fiberglass filters for the years 1979-1983, were used to tabulate the standard values. The parameters chosen were TSP, As, Cd, Cu, Pb, and Zn. Correct calculations of X values will produce a zero mean of all X values for the selected parameter.

Table 13 shows a comparison between Whatman 41 and Fiberglass A/E and parameter percent by weight of total particulate loading using Anaconda's data tabulated in Tables 9-12.

A comparison of parameter percent by weight with MERDI's data is not possible because TSP weight by MERDI was determined on fiberglass filters while heavy metals were determined on Whatman 41. Anaconda's and MERDI's data from Whatman 41 show close agreement if it is assumed that the total weight on the



DATA REDUCED FROM VALUES
BY THE ANACONDA MINERALS CO.
ARITHMETIC MEANS

FIGURE 2, STANDARDIZED VALUES
COMPARING TSP AND HEAVY METALS

fiberglass is the same as the weight on the Whatman. A 12 percent weight correction (Table 9, 1979 results) would result in very close agreements.

TABLE 13. PERCENT BY WEIGHT OF TOTAL PARTICULATE LOADING - ANACONDA DATA

Parameter	Whatman 41	Fiberglass
Benzene Soluble (Hydrocarbon)	7.3	10.7
Metals (Cu, Pb, Cd, As, Zn)	1.9	0.9
Ca	3.8	---
Fe	2.7	1.9
SO_4	3.7	(8.7)*
Mo	---	0.1
TOTAL	19.4	13.6

*Not included in total.

Fiberglass filters produced lower values of metals compared to Whatman filters. Both Anaconda data and MERDI analytical data account for approximately 20 percent of the total particulate weight. The other 80 percent in the TSP is not defined. Future sampling should address the following.

1. Determine the percent of crystalline silica as quartz, tridymite, and cristobalite in the total particulate loading.
2. Analyze the synergistic or additive effect on the human body by heavy metals in low concentrations.
3. Determine if fiberglass filters give lower than acceptable values for heavy metals analyzed.

Historically, air quality north of Interstate 90/15 and east of Main Street has been degraded by active mining operations and traffic dust generated from the Butte city streets. The actual contribution of each cannot be determined from the data studied. With mining operations suspended, only time

will tell what air quality change will occur as a result of the suspension. Large disturbed unreclaimed areas including the Berkeley Pit, East Berkeley Pit, waste dumps, leach dumps, and tailings pond will continue to be a potential source of dust emissions into the local air shed.

D. HYDROMETRICS

HYDROMETRICS analyzed environmental impacts and conducted a rehabilitation study of inactive mines and waste dumps for the Anaconda Minerals Company (63). The field investigation of the mine dumps included describing the existing soils and collecting soil samples from representative areas for laboratory analysis. The areal extent and general configuration (i.e., dump slope angle) were also recorded.

The following paragraphs are directly quoted from Reference 63.

> "Mine waste dumps in the Butte area typically consist of disintegrated waste rock and are essentially barren of vegetation. Thirteen sites in and around Butte were sampled to determine typical physical and chemical characteristics of this waste rock material. [Table 14] These sites were chosen to be representative of the 109 mines and dumps examined as part of this study. Samples were collected from the surface down to a depth of 24 inches and were air-dried.
>
> Based on laboratory analysis of soil samples, Butte area mines and waste dumps can be grouped into two general categories. Soils at most sites consist of low pH, sandy loam materials with high concentrations of water soluble aluminum and manganese. Water soluble copper and zinc concentrations are often also high at these sites and several sites have high electrical conductivities. Site BR-117 is typical of this group. The second general group of sites have near neutral pH values, low electrical conductivities and low concentrations of water soluble metals. Concentrations of total metals at these sites (indicated by the aqua regia digestion analyses) are high but the metals are less available to plants. The analysis of site BR-108 is typical of these sites. Samples from both groups commonly have high concentrations of aqua regia soluble arsenic and lead as well as other metals. All soils analyses showed low concentrations of major plant nutrients.
>
> Most mine sites and dumps in the Butte area are barren or are sparcely vegetated. Natural revegetation has succeeded on a few sites but the cover is generally sparse and consists primarily of weedy species. Major deterrents to revegetation of the mine sites and dumps include steep slopes, sandy soils which have little water-holding capacity, low plant

TABLE 14. SOILS ANALYSIS - ANACONDA RECLAMATION PROJECT

ALL RESULTS ARE EXPRESSED AS PPM (μG/G) UNLESS NOTED OTHERWISE

Site Name	Plutus	Little Sarah	Sankey	Nettie (incl.) + Nettie 2	Travona
Site No.	BR-100	BR-103	BR-106	BR-108	BR-113
1. Sample Depth (in.)	0-24	0-24	0-24	0-24	0-6
2. pH (Std. units water sol.)	6.0	6.2	2.2	6.8	7.3
3. Elec. Cond. (mmhos/cm)	0.79	0.51	6.85	1.20	0.79
4. Calcium (water sol.)	61	30	459	286	80
5. Magnesium (water sol.)	7	6	23	16	62
6. Sodium (water sol.)	3	2	17	4	10
7. Chloride (water sol.)	2.3	2.3	3.0	2.9	10.0
8. Sulfate (water sol.)	484	263	6880	713	532
9. Sulfur (HCl rinsed)	6400	13100	6800	1950	4600
10. Aluminum (water sol.)	0.2	0.1	147	<1	<0.1
(ammonium acetate sol.)	--	--	--	72	16.7
(aqua regia)	--	--	--	821	3025
11. Arsenic (hot water sol.)	<0.02	<0.02	12	<0.02	<0.02
(aqua regia)	--	--	--	1.60	78.2
12. Boron (hot water sol.)	<0.1	<0.1	0.7	<0.1	0.1
(aqua regia)	--	--	--	27	49.3
13. Cadmium (water sol.)	--	--	--	0.02	<0.01
(aqua regia)	--	--	--	7.9	2.6
14. Copper (water sol.)	<0.1	<0.1	7.1	0.02	<0.1
(ammonium acetate sol.)	--	--	--	29	1.3
(aqua regia)	--	--	--	67	44.5
15. Iron (aqua regia)	--	--	--	--	26000
16. Manganese (water sol.)	147	93	242	1.3	<0.1
(ammonium acetate sol.)	--	--	--	2445	364
(aqua regia)	--	--	--	23800	7640
17. Mercury (aqua regia)	--	--	--	0.40	0.101
18. Molybdenum (water sol.)	--	--	--	<0.1	<0.02
(aqua regia)	--	--	--	4.7	<1
19. Nickel (aqua regia)	--	--	--	1.9	44.6
20. Lead (aqua regia)	--	--	--	1779	79.9
21. Selenium (hot water sol.)	--	--	--	<0.02	<0.02
(aqua regia)	--	--	--	<0.02	<0.02
22. Zinc (water sol.)	3.8	0.5	20.9	0.4	<0.1
(ammonium acetate sol.)	--	--	--	894	7.6
(aqua regia)	--	--	--	2580	276
23. Nitrate-N (water sol.)	--	--	--	<1.0	3.7
24. Phosphorus (Bray Method)	--	--	--	17.9	2.5
25. Potassium (amm. acetate)	--	--	--	110	128
26. Sand (%)	65	67	65	69	77
27. Silt (%)	14	16	16	15	15
28. Clay (%)	21	17	19	16	8
29. Vegetative Cover (%)	<1	<1	<1	<1	1-25
30. Textural Class	Sandy Clay Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam

Travona	Emma Waste Dump	Colorado	Butte- New England	Kelley	New Era 344	Mtn. Con
BR-113	BR-117	BR-118	BR-143	BR-156	BR-158	BR-179
6-24	0-12	0-24	0-24	0-24	0-24	0-24
7.3	2.5	2.6	2.8	2.7	2.8	2.8
1.15	5.00	3.93	10.4	4.03	1.62	3.09
136	775	531	507	770	34	669
111	154	71	618	91	23	80
9	1	63	1780	2	30	27
9.2	<5.0	5.1	9.7	19.2	4.4	6.2
747	3360	3200	11300	2560	1100	2580
9400	6400	25400	56400	4480	6000	10600
<0.1	95.5	64.4	168	85.5	90	94.7
--	412	--	--	--	--	114
--	5300	--	--	--	--	1925
<0.02	0.50	1.20	0.80	0.08	0.12	0.14
--	222	--	--	--	--	201
<0.1	<0.1	0.2	0.2	<0.1	<0.1	0.1
--	<0.1	--	--	--	--	59.9
--	0.76	--	--	--	--	0.37
--	6.0	--	--	--	--	4.8
<0.1	177	104	1460	52.5	23.1	54.7
--	466	--	--	--	--	59.3
--	945	--	--	--	--	360
--	47000	--	--	--	--	33000
<0.1	91.0	21.3	289	40.6	7.9	34.3
--	118	--	--	--	--	38.3
--	342	--	--	--	--	284
--	0.70	--	--	--	--	0.622
--	<0.02	--	--	--	--	<0.02
--	12.0	--	--	--	--	4.2
--	4.5	--	--	--	--	33.1
--	560	--	--	--	--	1210
--	<0.02	--	--	--	--	<0.02
--	<0.02	--	--	--	--	<0.02
<0.1	235	201	427	160	165	115
--	237	--	--	--	--	140
--	790	--	--	--	--	593
--	0.3	--	--	--	--	1.0
--	6.0	--	--	--	--	9.0
--	23.0	--	--	--	--	9
74	63	66	55	69	71	72
13	23	11	22	17	16	14
13	14	23	23	14	13	14
1-25	<1	<1	1-25	1-25	<1	<1
Sandy Loam	Sandy Loam	Sandy Clay	Sandy Clay	Sandy Loam	Sandy Loam	Sandy Loam

Alice	Alice	Glengarry
BR-203	BR-203	BR-205
0-6	6-24	0-24
3.3	3.1	6.6
1.79	2.83	0.45
362	639	139
47	81	23
14	21	15
2.2	3.1	1.6
1490	2560	228
2100	2400	16700
32.9	65.1	<0.1
334	--	--
3355	--	--
0.03	0.06	<0.02
88.2	--	--
0.2	<0.1	<0.1
52.4	--	--
0.11	--	--
2.3	--	--
2.9	3.5	<0.1
9.8	--	--
88.2	--	--
26000	--	--
128	187	<0.1
232	--	--
2190	--	--
0.244	--	--
<0.02	--	--
<1	--	--
15.7	--	--
482	--	--
<0.02	--	--
<0.02	--	--
33.3	70.2	<0.1
100	--	--
397	--	--
3.3	--	--
6.0	--	--
48	--	--
77	76	80
16	13	11
7	11	9
<1	<1	--
Loamy Sand	Sandy Loam	Loamy Sand

> nutrient concentrations, and in the case of low pH soils, concentrations of water-soluble metals which inhibit germination and are toxic to plants.
>
> Reclamation techniques for sites with near neutral pH values must include fertilization and establishment of topographic and microclimatic environments which will minimize the dry conditions common to these coarse-grained materials. Materials with low pH values also will require the addition of lime to raise the pH to levels suitable for germination and stand establishment."

Utilizing HYDROMETRICS estimated disturbed acreage (63) for the mining operations studied in the abandoned mine land project, the following summary of unreclaimed area was calculated:

Acres	
220	Underground Mines and Associated Dumps
46	Alice Open Pit and Dumps
22	Syndicate Open Pit and Dumps
62	Clark Tailings
350	TOTAL Area of Abandoned Mine Lands

Two hundred and eighty four acres of the AML (not including the Clark Tailings) lie within the boundaries of Butte and Walkerville. In other words, almost one-half of a square mile of abandoned mine lands are located within the urban area, surrounded by or adjacent to residential areas. These disturbed mine lands have a significant negative impact on the quality of the environment, and the personal safety and health of the affected population.

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Waste dump surfaces tend to be deficient in vegetation cover and are susceptible to runoff events. Sheet wash and rill and gulley erosion are significant on the steep dump slopes. Because of area topography, precipitation runoff from the waste dumps associated with the abandoned mine lands deposits sediment on the city streets, on any flat-lying areas including playgrounds and within the storm sewer system. Most of the waste dumps are barren or sparsely vegetated and commonly have slopes at or near the angle of repose. As a result, erosion is facilitated.

The passage of traffic over mine dump material deposited on city streets causes a breakdown in particle size, resulting in the formation of finer and finer particles. The percentage of particulate dust that can become airborne is continuously increased. This situation plus plugging of the storm sewer system requires that streets below major dump erosion areas be cleaned frequently throughout the year. Despite deligent efforts by the Public Works Department, city streets below mine dumps are dirty and a source of airborne suspended particulates throughout much of the year. A constant clean-up battle is being waged by the Butte-Silver Bow Public Works Department (65).

The typical spring street sweeping program in the northwest section of Butte (encompassing all but Walkerville and the Clark Tailings areas of the abandoned mine lands under study) will require the services of two street sweepers for about three weeks (65). In addition to the street sweepers, water tankers are concurrently used to flush the streets. The street sweepers will remove 1000 to 1500 tons of material (primarily dirt and dust containing 10 percent moisture) from this area. Some of this material is laid down during the winter street sanding program.

The same area will be cleaned again in the late summer/early fall. About 100 to 300 tons of material will be swept from the streets at that time. If a significant precipitation event (rain) occurs, the city may have to utilize a grader, a payloader and trucks to remove mine waste dump material deposited on the city streets below particularly vulnerable abandoned mine land dumps.

The Clark Tailings are eroded by strong winds, creating air quality complaints from adjacent landowners (63). Water-wind erosion and a subsequent increase in airborne particulates in the general area are reported to occur periodically. A dust suppressant (possibly asphalt) was applied to the tailings

in the past, but the coating is in poor condition because of age and trafficking by off-road vehicles.

Thirteen samples of fine particulate material were obtained from the streets of Butte that were located below abandoned mine lands. These samples were obtained with a street sweeper provided by the Butte-Silver Bow County Government.

A composite sampling of multiple surface locations (on approximately 250-300 feet centers) on the Clark Tailings Area was conducted. The particulate material was vacuumed up from the surface of the tailings through an 18-mesh fine wire screen. An industrial vacuum cleaner and portable electric generator were utilized.

Three samples of fine particulate matter were obtained from the surface of three baseball/softball/playground areas. These recreation areas are located below abandoned mine land areas. These samples were obtained with the use of the fine wire screen, the industrial vacuum cleaner and the portable electric generator.

Table 15 is a description of the sites sampled during this dust sampling program. The sample sites are also noted on the map in Appendix 1.

Seventeen samples varying in size between 14 and 80 pounds were collected for dry sieve analysis. Sample numbers 5 and 6 were combined because both samples came from a generally similar source area. The 16 individual dust samples collected were classified by particle size using Tyler sieves and a Ro-Tap sieve vibrator. The fraction of interest consisted of all particles less than 45 microns in size. This size is equivalent to minus 325 mesh Tyler.

The original samples were reduced in size to 16 samples weighing 5 kg by selectively pulling approximately 300g of sample from various areas of the original sample until a 5 kg representative sample was obtained.

TABLE 15. DESCRIPTION OF SURFACE DUST SAMPLING PROGRAM

A. Sweeping of Butte City Streets

Sample Number	Location	Remarks
1	South of Belmont Mine Area	6 blocks sampled
2	East Mercury Street, Belmont Mine to Colorado Mine	7 blocks sampled
3	East and South of Emma Mine	2 blocks sampled
4	West and South of Ophir Dump	2 blocks sampled
5*	North, East and South of Travonia Mine	4 blocks sampled
6*	Star West Dump Area	3 blocks sampled
7	Alley, South of Original Mine	3 blocks sampled
8	Woolman Street, South of Steward Mine	3 blocks sampled
9	Buffalo Street, Below Mtn. Con Mine	5 blocks sampled
10	South of Buffalo Mine, Syndicate Open Pit	7 blocks sampled
11	Caledonia Street, South of Anselmo Mine	3.5 blocks sampled
12	Road West of Alice Open Pit Dump	7-8 blocks sampled
13	East and West of Lexington Mine	8 blocks sampled

B. Surface Sampling with Industrial Vacuum Cleaner

Sample Number	Location	Remarks
14	Clark Tailings Area	On 250-300 foot grid
15	Little League Baseball Field One Block South of Anselmo Mine	25 sample points
16	Little League Baseball Field on Missoula Avenue	16 sample points
17	Ball Field/Playground Area South of Alice Open Pit Dump	20 sample points

*Samples 5 and 6 were combined into one composite sample for chemical analysis purposes.

From the 5 kg samples, 500 cc was pulled for screening. The 500 cc sample was weighed and then screened through Tyler sieves stacked in the following order:

18 mesh
45 mesh
85 mesh
100 mesh
150 mesh
200 mesh
325 mesh
pan

All samples were vibrated for 15 minutes. At the end of that time, all material greater than 100 mesh was discarded. The material less than 100 mesh was classified, weighed and bagged. After each sample run, the sieves were cleaned using compressed air.

Table 16 lists the data obtained by the screen analysis. Weights of the original samples vary, probably due to density differences caused by moisture content, void space and compaction, and particle size. All weighing was done on an Ohaus beam balance and approximated to the nearest gram.

The remaining material in the 5 kg samples was classified by passing it through 85 mesh Tyler sieves. All material greater than 85 mesh, which constituted the greatest bulk, was discarded. Material less than 85 mesh was bagged, labeled and stored for future reference.

The 16 samples of final screened material (-325 mesh) were analyzed by the MultiTech chemical laboratory in Butte, Montana. The following analyses were performed on the minus 45 micron particulate matter.

1. Total non-volatile hydrocarbons by Freon extraction. Duplicate extraction of each sample.
2. Digestion by HF, $HClO_4$, HNO_3 acid mix as per USGS Circular 841. Two randomly chosen samples were digested in duplicate.

TABLE 16. WEIGHT DISTRIBUTION OF SCREENING AS-COLLECTED SURFACE DUST SAMPLES

	Sample Weights (grams)					
Sample Number	Initial Weight	+100 Mesh	-100 Mesh	-150 Mesh	-200 Mesh	-325 Mesh
1	802	455	133	93	84	37
2	910	656	96	67	62	29
3	870	685	94	49	30	12
4	832	591	79	66	71	25
5 & 6	898	580	119	84	90	25
7	714	459	93	67	69	26
8	920	620	113	82	68	37
9	897	657	102	64	48	26
10	837	559	102	78	65	33
11	854	523	129	90	74	38
12	876	591	109	73	63	40
13	875	562	116	81	74	42
14	680	448	64	87	65	16
15	784	437	89	71	99	88
16	799	498	79	65	74	83
17	840	485	87	73	89	106

3. Analysis of digestion solutions. Duplicate analyses of each digestion solution for Pb, Cd, As, Bi, Zn, Fe, Ca, Cu, Mn, Ni, Cr, and $SO_4^=$. Metals were analyzed by flame AA, As by hydride generation, and $SO_4^=$ by turbidimetry.
4. Extraction and analysis for free silica by P & CAM 105 (NIOSH). Duplicate extractions of two randomly chosen samples and duplicate AA analysis of all sample solutions were done.

Results of these analyses are reported in Table 17.

Analysis of Butte dust samples confirms the presence of metals that can cause cancer. These include arsenic, cadmium chromium, nickel, iron, lead, and zinc. Other heavy metal present in the samples are bismuth, copper and manganese. High levels of both iron and free silica are also present in potential airborne dust sources. These metals are most likely in some oxide or sulfide form.

In 1978, the Montana Air Quality Bureau sampled surface materials from various Butte area fugitive emission sources including: surface loading from paved and unpaved roadways; and aggregate materials from various locations in the Berkeley Pit (33e). These samples were subsequently analyzed for silt, moisture and metals content of the silt-sized material. The results are shown in Table 18.

The metals values of the silt-sized material are much lower than some of the corresponding values in Table 17. The results probably reflect the fact that the sample sites in Table 18 were not proximate to abandoned mine land dumps. The silt material probably reflects material transported from adjacent non-mine dump sources by vehicles, wind and precipitation. However, even the lower values for As, Cd, V, Cu, and Zn in Table 18 are much higher than similar values in Missoula and Billings.

TABLE 17. CHEMICAL ANALYSIS OF DUST SAMPLES FROM CLARK TAILINGS AREA, STREET SWEEPINGS AND PLAYGROUNDS

		Chemical Analysis of Minus 45 Micron Dust Screened Through Minus 325 Mesh Tyler Screen (μg/g)														Total
Sample Number	Associated Mining Area	As	Bi	Ca	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Zn	SO_4	SiO_2 (%)	Non Vol. H.C.	Percent Ident.
1		181	<50	46,500	12.6	425	1,410	61,800	1,010	55	868	1,970	34,100	47.3	1,900	62.33
2		141	<50	45,800	11.4	400	1,330	60,300	1,070	53	742	20,600	36,300	33.9	2,400	50.81
3		131	<50	54,000	19.5	790	1,500	98,000	9,580	93	1,510	5,450	60,900	38.2	4,500	61.85
4		1,580	60	29,000	34.8	88	10,500	87,500	6,600	<50	1,070	8,090	112,000	43.8	1,200	69.58
5 & 6		271	<50	38,900	29.8	242	1,100	52,600	19,800	<50	2,240	8,240	49,100	36.3	2,000	53.76
7		475	<50	60,800	38.1	490	4,400	55,800	1,900	61	2,160	8,930	56,300	42.5	4,800	62.12
8		170	<50	43,300	13.0	253	2,350	60,800	1,400	<50	724	1,930	51,500	43.0	1,800	59.43
9		72	<50	24,000	22.6	960	2,100	76,800	2,300	<50	4,450	5,300	86,300	49.9	1,600	70.30
10		459	<50	37,500	20.9	147	1,830	59,400	1,380	<50	1,380	4,850	48,800	47.6	4,000	63.59
11		284	<50	46,100	24.7	314	1,550	59,200	2,000	<50	1,430	5,500	56,300	49.4	4,000	67.08
12		80	<50	35,300	12.7	118	256	53,000	4,550	<50	1,230	2,380	37,500	40.9	1,900	54.54
13		46	<50	38,300	22.3	129	485	53,800	3,630	<50	1,430	3,880	43,500	41.6	1,800	56.31
14		1,600	<50	7,030	31.2	15	562	48,500	34,200	<50	2,700	10,300	134,000	68.4	200	92.32
15		398	<50	23,100	25.1	64	1,680	38,600	3,050	<50	604	6,740	36,000	44.4	100	52.21
16		240	<50	25,000	22.4	58	290	44,400	5,330	<50	798	6,880	33,000	44.0	--	55.61
17		106	<50	31,000	16.4	72	279	60,300	5,180	<50	874	2,980	38,800	19.9	400	33.91

TABLE 18. SUMMARY OF LABORATORY DATA FOR FIELD SAMPLES OF OPEN DUST SOURCE MATERIAL (33e)

Sample No.	Material	Silt Content (%)	Metals Content of Silt-Sized Material(μg/g)							
			Pb	As	Cd	V	Cu	Fe	Al	Zn
14	Residential paved roadway - curb area near AQB monitoring site/Hebgen Park	9.7	865	55.8	14.3	139	1,500	33,100	55,800	1,813
15	Residential paved roadway - travel lanes - near AQB monitoring site/Hebgen Park	10.6	754	37.7	7.55	189	1,160	20,200	57,200	1,270
16	Harrison Ave. - curb area	11.3	762	56.6	16.1	270	826	44,600	56,400	3,980
17	Harrison Ave. - travel lanes	5.0	1,420	36.7	5.53	609	1,390	47,200	53,200	4,880
20	Montana St. - paved road - curb area	8.4	1,620	23.8	8.66	1,160	1,580	63,500	51,900	1,620
21	Montana St. - paved road - travel lanes	6.6	1,080	11.4	3.48	414	873	22,500	45,000	1,150

According to the AQB, Environmental Impact Statement (69), several studies have shown that lung function problems are prevalent in areas with high particulate and suspended sulfate levels. During the 1975 Pittsburgh pollution episode, fourteen deaths were recorded directly attributable to pollution. TSP levels averaged about 450 $\mu g/m^3$ and suspended sulfate averaged 57 $\mu g/m^3$. Van Der Lende et al. (69) assessed from another study that the pollutant having the greatest effect to lung function problems was that of suspended sulfate. Also, Hammer, 1977 (69), found that lower respiratory diseases in children were about 1.2 to 2.0 times greater in Birmingham, Alabama, than in Charlotte, North Carolina. Pollution records from both cities (1967-1972 avg.) show that Birmingham's TSP and suspended SO_4 levels were about 1.8 times and 1.3 times higher than in Charlotte, respectively.

The State of Montana under 16-2.14(1)-S14040 Ambient Air Quality Standards, 1967, included a rule for suspended sulfate. The adopted standard was as follows:

1. 4 $\mu g\ m^3$, maximum allowable annual average
2. 12 $\mu g/m^3$, not to be exceeded over 1 percent of the time

The sulfate standard has since been deleted from the present Montana Air Quality rules, but the concept and objectives are still worthy of considering in this AML study.

Chemical analyses of <45 micron mine dump dust in $\mu g/g$ from Table 17 were reduced to estimated ambient concentrations in $\mu g/m^3$ in Table 19. Calculations were performed by assessing a high-volume dust loading of 75 $\mu g/m^3$ and originating from street dust below the respective abandoned mine dumps. An attempt was made to correlate these concentration values with Threshold Limit Values (TLV) adopted by the American Conference of Governmental Industrial Hygienists (ACGIH), 1983-1984. Ratios of ambient concentrations to actual TLV's (mixture hazard) range from 0.03 to 0.13. It should be noted, however, that working

TABLE 19. CALCULATED HAZARD POTENTIAL OF MINUS 45 MICRON DUST IN AMBIENT AIR (Assuming 75 $\mu g/m^3$ TSP)

Concentrations in $\mu g/m^3$, calculated from Table 17.

Pollutant	TLV	Emma Mine	Ophir Mine	Travonia & Star West Mines	Original Mine	Mtn. Con Mine	Anselmo Mine	Clark Tailings
As	200	0.010	0.119	0.20	0.036	0.005	0.021	0.120
Bi	10,000	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Ca	5,000	4.050	2.175	2.918	4.560	1.800	3.458	0.527
Cd	50	0.001	0.003	0.002	0.003	0.002	0.002	0.002
Cr	500	0.059	0.007	0.018	0.037	0.072	0.024	0.001
Cu	1,000	0.113	0.788	0.083	0.330	0.158	0.116	0.042
Fe	10,000 as salts	7.350	6.563	3.945	4.185	5.760	4.440	3.638
Mn	5,000	0.719	0.495	1.485	0.143	0.173	0.150	2.565
Ni	1,000	0.007	< 0.004	< 0.004	0.005	< 0.004	< 0.004	< 0.004
Zn	5,000	0.409	0.607	0.618	0.670	0.398	0.413	0.773
SiO_2	(%) TLV	28.650 728	32.850 641	27.225 763	31.875 659	37.425 567	37.050 573	51.300 420
HC	N.A.	0.338	0.090	0.150	0.360	0.120	0.300	0.015
Mixture Hazard[1]		0.05	0.06	0.04	0.03	0.07	0.07	0.13

1. Mixture hazard calculated using formula by ACGIH (based on occupational work place standard): $\frac{C_1}{T_1} + \frac{C_2}{T_2} + \dots \frac{C_n}{T_n}$ = Total (Pages 48 and 49, Ref. 70)

	Montana Ambient Stand.	Emma Mine	Ophir Mine	Travonia & Star West Mines	Original Mine	Mtn. Con Mine	Anselmo Mine	Clark Tailings
Pb	1.5	0.113	0.080	0.168	0.162	0.334	0.107	0.203
SO_4	4.0 (old)[2]	4.568	8.400	3.683	4.223	6.473	4.223	10.050
Mixture Hazard[1]		1.22	2.15	1.03	1.19	1.84	1.13	2.65

2. 1967 Montana Ambient Air Standard (repealed)

place TLV's as adopted by ACGIH are very conservative when compared to existing ambient air standards. Ambient air standards for the same toxic agent are approximately one-tenth to one-hundredth the occupational work place standard (TLV). The mixture hazard for airborne dust containing the combination of pollutants ranges from 1/8 to 1/33 the ACGIH work place standard. The effect of the mixture of pollutants on the human body has been assumed additive. This may or may not be realistic, depending on (1) the site of action of the toxic agent in the human body and (2) the presence or absence of synergistic effects of the pollutant within specific human body sites.

The second part of Table 19 is a calculation of the potential hazard for Pb and SO_4 in abandoned mine land areas, based on current (Pb) and repealed (SO_4) Montana Ambient Air Standards. The hazard of this mixture to the general population is high, ranging from 1.03 to 2.65. The major contributor is the SO_4, ranging from a hazard factor of 0.92 to 2.51.

In both cases, the mixture hazard is the sum of various toxic agents that would not exclusively affect the human respiratory system. But the overall implications from the data presented indicate a potential hazard to human health from breathing air containing 75 $\mu g/m^3$ of dust originating from the following abandoned mine land sites.

1. Emma Mine
2. Ophir Mine
3. Travonia Mine and Star West Dumps
4. Original Mine
5. Mountain Con Mine
6. Anselmo Mine
7. Clark Tailings

Chemical mass balance analyses were made by the Montana Air Quality Bureau (31) in 1982. The goal of this study was to determine the sources in the Butte area contributing the particulates causing the elevated total suspended particulate concentrations. Thirty-four elements were analyzed for in sixteen grab and vacuum samples from various sources including: baseball diamond, streets, parking lot, mine dump, Berkeley Pit service and haul roads, Berkeley waste, copper concentrate, and Stauffer Chemical Company plume.

Four of the samples were collected in the area encompassed by the Abandoned Mine Land Study. The locations sampled and the results of the analyses for 17 elements are summarized in Table 20. The samples were separated into fine (0 to 2.5 microns) and coarse (2.5 to 15 microns) fractions for analysis. A comparison of the results reported in Table 17 are similar to the comparable analyses in Table 20.

The close agreement of the results from the two studies indicate the potential widespread nature of the distribution of street dirt and potential airborne dust that contains significant quantities of toxic metals, sulfate and free silica. The analysis of bromine-to-lead ratio in the particulate indicated that the bulk of the lead in the airborne particulate was from lead-bearing ores, not leaded gasoline and vehicle exhaust.

F. Discussion

In 1978, a portion of Butte (north of Interstate 90/15 and east of Arizona Street) was designated as a non-compliance area. In 1981, the Montana Air Quality Bureau estimated the total particulate emissions in the Butte area at 31,861 tons per year (62). This estimate included 20,297 tpy from the Anaconda Minerals Company operations and 11,564 tpy from all other sources in the city of Butte. The 1983 Montana State Implementation Plan recommended that a maximum

TABLE 20. SUMMARY OF CHEMICAL MASS BALANCE ANALYSIS BY MONTANA AIR QUALITY BUREAU (31)

Element	Sample B-100 + B-101*		Sample B-102**		Sample B-103***	
	Fine, Percent	Coarse, Percent	Fine, Percent	Coarse, Percent	Fine, Percent	Coarse, Percent
Al	11.343 ± 0.687	8.325 ± 0.422	11.647 ± 0.663	9.189 ± 0.490	11.447 ± 0.838	9.769 ± 0.499
Si	31.466 ± 1.880	25.568 ± 1.290	31.403 ± 1.767	28.217 ± 1.485	25.023 ± 1.806	24.576 ± 1.248
P	0.363 ± 0.029	0.240 ± 0.014	0.571 ± 0.037	0.426 ± 0.026	0.556 ± 0.047	0.310 ± 0.017
S	0.889 ± 0.077	0.655 ± 0.038	1.054 ± 0.079	0.780 ± 0.054	4.944 ± 0.390	2.691 ± 0.146
Cl	0.406 ± 0.038	0.290 ± 0.017	0.158 ± 0.021	0.131 ± 0.015	0.097 ± 0.035	0.096 ± 0.013
K	2.113 ± 0.132	2.242 ± 0.114	1.902 ± 0.112	2.014 ± 0.109	2.304 ± 0.174	2.093 ± 0.108
Ca	7.157 ± 0.432	5.182 ± 0.264	4.945 ± 0.282	5.254 ± 0.280	1.087 ± 0.084	1.937 ± 0.100
Ti	0.377 ± 0.025	0.501 ± 0.026	0.402 ± 0.025	0.511 ± 0.028	0.403 ± 0.033	0.519 ± 0.027
Cr	0.026 ± 0.004	0.025 ± 0.002	0.027 ± 0.004	0.026 ± 0.003	0.052 ± 0.007	0.036 ± 0.002
Mn	0.217 ± 0.014	0.231 ± 0.012	0.173 ± 0.011	0.198 ± 0.011	0.089 ± 0.009	0.108 ± 0.006
Fe	4.456 ± 0.270	4.920 ± 0.249	4.093 ± 0.234	4.217 ± 0.224	14.384 ± 1.039	9.106 ± 0.464
Ni	0.000 ± 0.003	0.004 ± 0.001	0.013 ± 0.004	0.008 ± 0.002	0.014 ± 0.005	0.010 ± 0.001
Cu	0.143 ± 0.011	0.126 ± 0.007	0.197 ± 0.013	0.184 ± 0.011	0.353 ± 0.029	0.272 ± 0.014
Zn	0.314 ± 0.021	0.294 ± 0.015	0.355 ± 0.022	0.325 ± 0.018	0.650 ± 0.050	0.696 ± 0.036
As	0.027 ± 0.010	0.009 ± 0.003	0.014 ± 0.008	0.015 ± 0.006	0.051 ± 0.025	0.043 ± 0.007
Cd	0.000 ± 0.030	0.001 ± 0.005	0.000 ± 0.024	0.006 ± 0.015	0.031 ± 0.044	0.008 ± 0.008
Pb	0.211 ± 0.019	0.196 ± 0.011	0.225 ± 0.017	0.186 ± 0.013	1.197 ± 0.092	0.633 ± 0.033

* Hebgan Park - Baseball Diamond, Parking Lot, Bus Parking, Service Area
** Hebgen Park - First Street
***Mine Dump - Atlantic and Second Streets

of 25,400 typ be emitted to the atmosphere in order for Butte to quality as an air quality attainment area.

The Montana Air Pollution Study (MAPS) estimated that the annual emissions of metals and sulfuric acid totaled 2724 tons per year (33h).

The annual background total suspended particulate level for the Butte area appears to be about 20 $\mu g/m^3$ of air. The particulate level for Walkerville ranges from 22 to 45 $\mu g/m^3$. The suspended particulate level at air sampling stations in uptown Butte area of the abandoned mine land study ranged from 48 to 77 $\mu g/m^3$ (Table 6).

Respirable particulate was sampled as part of the MAPS program (56). Dichotomous samplers split the respirable particulates (15 microns or less) into coarse (2.5 to 15 microns) and fine (less than 2.5 microns) fractions. The fine fraction (less than 2.5 microns) contributed 34 to 44 percent of the total respirable particulates.

Since 1978, the Montana Air Quality Bureau has designated Summit Valley south of Interstate 90/15 as an attainment area for total suspended particulate. MERDI/MultiTech data was utilized in establishing this designation. The Butte Summit Valley does not appear measurably deteriorated by the abandoned mine lands under study. However, the Clark Tailings area has not been studied in detail by any air sampling program.

The Anaconda Minerals Company high-volume data was analyzed for the Belmont Mine, Lexington Mine, Kaw Avenue, and Butte Operations Shop-Montana Power Company air monitoring stations for the 1977-83 period. Air quality at the Belmont Mine station has consistently been in violation of the 24-hour National Secondary Standard and the 24-hour Montana State rule. The Kaw Avenue station exceeded the 24-hour state and federal standards several times in 1980 and 1981. The Montana Power and Lexington Mine stations had no violations.

The Anaconda high-volume samples were analyzed for heavy metals. Plotting the standardized values of the TSP and metal values show a definite trend that an increase in TSP carries with it an increase in heavy metal content.

The air sampling programs of the State of Montana, the Anaconda Minerals Company and MERDI/MultiTech have concentrated on determining the total mass of suspended particulate at the respective air sampling stations located throughout the Butte area. A review of available data shows that both Anaconda and MERDI analytical data account for up to approximately 20 percent of the total suspended particulate weight. The other 80 percent of the TSP is not defined. The Montana Air Quality Bureau air sampling program has not conducted any extensive analysis of the suspended particulate collected at the high-volume sampling stations. Future TSP analytical efforts should reflect an effort to ascertain the chemical/mineralogic content of the airborne particulate in the air shed over the Butte area. It is important to identify all the constituents in the suspended particulates in order to attempt to understand their potential synergistic effect upon the health of the local population.

HYDROMETRICS analyzed environmental impacts and a rehabilitation study of inactive mines and waste dumps for the Anaconda Minerals Company (63). Utilizing HYDROMETRICS data, the estimated disturbed acreage for the mining operations studied in the abandoned mine land project was calculated:

Acres	
220	Underground Mines and Associated Dumps
46	Alice Open Pit and Dumps
22	Syndicate Open Pit and Dumps
62	Clark Tailings
350	TOTAL Area of Abandoned Mine Lands

Two hundred and eighty-four acres of AML (not including the Clark Tailings) lie within the boundaries of Butte and Walkerville, surrounded by or adjacent to residential areas.

Precipitation runoff causes erosion of the abandoned mine land waste dumps and deposits sediment on the city streets. The vehicular traffic passing over the mine dump material deposited on the city streets causes a breakdown in particle size, resulting in the formation of finer and finer particles. The fine dust becomes readily airborne due to traffic and natural winds. The Butte city sweepers will remove 1000 to 1500 tons of material from the northwest section of the city alone during the springtime cleanup. About 100 to 300 tons of material will be removed from the same streets again in the late summer/fall. Individual precipitation events can cause extensive erosion of the abandoned mine lands, requiring the use of a grader, a payloader and trucks to remove the dirt from city streets below particularly vulnerable abandoned mine land dumps.

Adjacent land owners report that the Clark Tailings result in increased airborne particulates in the general area periodically (63). A dust suppressant was applied to the tailings in the past, but the coating is in poor condition now.

Thirteen samples of fine particulate material were obtained from Butte streets located below mine lands. A composite sample of dust from multiple surface locations was obtained from the Clark Tailings. Three samples of fine particulate material were obtained from the surface of three playground areas located below abandoned mine land areas. The samples were classified through a dry sieve. The fractions less than 45 microns (minus 325 mesh Tyler) were chemically analyzed. The analysis confirmed the presence of metals that can cause cancer, including arsenic, cadmium, chromium, nickel, iron, lead, and zinc. High levels of both iron and free silica are also present, along with bismuth, copper and manganese.

Calculations were performed by evaluating the mixture hazard of ambient air containing 75 $\mu g/m^3$ of dust originating from the street dust below the

respective abandoned mine dumps. The data indicates that a potential hazard to human health exists from breathing air containing 75 μg of dust/m^3 of air originating from:

1. Ophir Mine
2. Anselmo Mine
3. Emma Mine
4. Original Mine
5. Mountain Con Mine
6. Travonia Mine
7. Clark Tailings

It is recommended that a stabilization/reclamation plan be conducted for the first six mine dumps (excluding the Clark Tailings) in order to reduce the amount of material eroded from the dumps and deposited on the city streets. The Clark Tailings area has been excluded at this time due to the lack of data on its contribution to air pollution problems in the Butte area.

A chemical mass balance study was made by the Montana Air Quality Bureau in 1982. Four dust samples were collected from areas encompassed by the Abandoned Mine Land Study. The chemical analysis of the respirable fraction (0 to 2.5 microns and 2.5 to 15 microns) reported in Table 20 show close agreement with the results of the 16 previous analyses discussed and shown in Table 17. This close agreement indicates the potential widespread nature of the distribution of street dirt and potential airborne dust that contains significant quantities of toxic metals, sulfate and free silica.

The results of surface and underground mining operations are a part of the heritage of the population of Butte-Silver Bow County. Many of the natives have grown up surrounded by mining operations. Most natives are familiar with at least the surface manifestations of mining; a large percentage of the male

population has worked in the mines at one time or another. During the late nineteenth century, Butte was the largest mining/milling/smelting complex in the world.

The local population has come to accept a close, physical relationship with active, dormant and abandoned mining operations. Only a limited pattern of public and political expression has been raised concerning the local negative impacts of current and historical mining operations.

Day-to-day familiarity with mines, mining activities and mining consequences have led to a general acceptance of the environmental and physical consequences of mining and associated activities. In great measure, this reflects the economic fact that mining has been the primary basis of livelihood in the community.

In the past, there has been a general lethargy with respect to a strong local base of criticism voiced against any of the negative impacts from abandoned mining operations. Specifically, an intensive evaluation of the effect of abandoned mine lands on the health and welfare of the local population has never been demanded, or even suggested, until recently.

Although some public health oriented studies have been conducted in various mining communities, the major emphasis of such studies on the public health has normally been directed to towns and cities that include base-metal smelting operations. Even at that, until recently most smelter pollution studies have addressed the impacts of the toxic effluents on animal and plant life in the surrounding region. Only in recent years has any real attention been devoted to ascertaining the impacts of the smelters on the health of the local population.

A case in point is the American Smelting and Refining Company in East Helena. A base-metal smelter has operated there since the late nineteenth century. Recently, ASARCO, the Montana State Highway Department, the Montana

Department of Health and Environmental Sciences, and the City of East Helena have agreed on a clean-up plan (66). The objective of the effort is to reduce the ambient air lead levels in the community from the current level of approximately 3 micrograms/meter^3 of air to below 1.5 micrograms/meter^3 of air within the next three years. Initial steps in the clean-up plan include:

1. Sealing the surface of a highway.
2. Resurfacing streets and parking lots.
3. Spreading new gravel in playground areas.
4. Routinely flushing and sweeping roads.
5. Sealing or isolating ore stockpiles at the ASRACO plant site.
6. Moving stockpiles farther from the community.
7. Planting trees and windbreaks to reduce wind erosion.

The least expensive steps will be taken first to control lead levels, with the more expensive measures to be used if necessary.

A similar program should be conducted in Butte with respect to the abandoned mine lands which have a negative impact on air quality. Air quality aspects, although difficult to quantify because of the lack of site-specific air quality monitoring efforts, are being addressed in this report. Radon-daughter sources and problems can only be speculated on at this time. But the potential should be recognized in light of the Montana Department of Health and Environmental Sciences report Evaluation of Radon Sources and Phosphate Slag in Butte (see Section VIII of this report).

According to Mr. J. Johnson, Director of Public Works for Butte-Silver Bow County, the following abandoned mine properties present existing erosion/deposition problems to the community (65):

1. Colorado Mine
2. Emma Mine

3. Travona Mine
4. Original Mine
5. Steward Mine
6. Buffalo Mine
7. Mtn. Con Mine
8. Anselmo Mine
9. Alice Open Pit

Chemical analyses of dust from streets located downgrade from these mines indicates the presence of toxic agents. These agents are known to be individually or jointly hazardous to human health. Available information points to the cumulative or synergistic effect of these toxic agents on the health of human lungs. Therefore, two factors are very obvious: (1) the dust containing the toxic agents can become readily airborne; and (2) Butte residents have had a higher than normal incidence of morbidity and mortality from diseases that area commonly associated with air pollution. The decrease in underground mining activity over the years and the suspension of the remaining surface mining in June 1983 may or may not affect the morbidity and mortality rates in the future.

VII. AIR POLLUTION ASPECTS OF SOCIOECONOMIC QUESTIONNAIRE

A socioeconomic survey of the population living adjacent to the abandoned mine land areas was conducted by ECONSULT, Inc. of Butte, Montana. The statistics on the survey include (1) 130 mailings and (2) 63 returns with 47 people responding to these survey questions:

> Are any abandoned mine land sites in your neighborhood
> a source of dust? Yes_____ No_____
>
> If yes, can you identify the location?

Thirty eight of the responses indicated Yes to the above question, and seventeen responses indicated No. The abandoned mine operations associated with the Yes answers are as follows:

Number of Responses (Yes)	Abandoned Mine
12	Anselmo Mine
6	Syndicate Open Pit
4	Alice Open Pit
3	Original Mine
2	Moose Mine
1	Mtn Con Mine
1	Buffalo Mine
1	Gagnon Mine
30	

The responses indicated that the sources of dust from these mine areas are (1) windblown and/or (2) material eroded from the mine dump areas, deposited on downgrade sites and entrained into the ambient air by other community activities and natural forces.

VIII. RADIATION

Short-lived radioactive radon-daughters which deposit and decay in the human respiratory system are a potential cause of lung cancer. The Montana Department of Health and Environmental Sciences has conducted a field study and investigated the potential sources of radon gas (radon-222) which contribute to the elevated ambient and indoor concentrations of radon and radon-daughters in Butte, Montana (67). The general results of the study are summarized as follows.

Indoor Measurements

Homes containing phosphate slag building materials, which were known to contain radioactive elements, were investigated. The initial concern over elevated radon-concentrations occurred when a basement in a Butte home was found to have radon progeny concentrations in excess of 0.25 WL. Indoor radon progeny concentrations of 0.02 WL or less were not considered to have a significant indoor radon problem based on the U.S. Surgeon General's guidelines for Grand Junction, Colorado, and the EPA standards for inactive uranium mill sites (10 CFR 192). Generally, radon progeny concentrations in homes do not exceed 0.02 WL where radon soil gas concentrations were less than 500 pCi/l. During 1979-1982, an initial screening of neighborhoods was conducted by the grab sample method (Table 21).

TABLE 21. INDOOR RADON PROGENY GRAB SAMPLE MEASUREMENTS IN BUTTE, 1979 - 1982 (67)

Working Level	Total Housing Units*
Less than 0.010	1,102
0.010 - 0.019	426
0.020 - 0.049	187
0.050 - 0.100	43
Greater than 0.100	13
TOTAL Samples	1,771

*A single family house or living unit in a multi-family structure is defined as a "housing unit."

Radon progeny measurements were conducted in 254 housing units with the use of Radon Progeny Integrating Sampling Units (RSIUP's). Annual average concentrations are shown in Table 22.

TABLE 22. AVERAGE ANNUAL CONCENTRATIONS OF RADON PROGENY IN HOUSING UNITS MEASURED WITH RSIUP'S

Working Level	Main Floor Measurements	Basement Measurements
Less than 0.010	58	9
0.010 - 0.019	39	12
0.020 - 0.050	76	16
Greater than 0.050	37	7
TOTAL Housing Units Measured	210	44

The working level (WL) is defined as any combination of radon-daughters or radon progeny in one liter of air that will result in the emission of 1.3×10^5 MeV (million electron volts) of potential alpha energy from the radioactive decay of the radon-daughters.

The working level concentration is an exposure level and not a dose rate. For radiation exposure purposes, the WL unit should be multiplied by the average breathing rate in liters per minute, by an average fractional retention of radon-daughters in the lung, and by the total time of exposure. In the industrial environment, the respiration rate and fractional retention are omitted and cumulative exposure is estimated as a product of WL and time. Cumulative exposures are given in working-level hours (WLH) or, more commonly, working-level months (WLM). An average exposure to 1 WLM for 8 hours is equal to 8 WLH. An average exposure to 1 WL for 4-1/3 weeks or 173 hours is equal to a WLM. Thus, 173 WLH equals 1 WLM. The Federal occupational health standard has established the maximum exposure level at 4 WLM per year. This indicates that all work places must maintain an average concentration of less than 0.33 WL.

Phosphate Slag

Phosphate slag produced at the Stauffer Chemical Company Plant near Butte contains elevated radium-226 levels. However, test work shows that radon emissions form the slag is not a significant health concern. The radium contained in the slag and phosphate ore are essentially the same. But the slag emits less than one percent as much radon as the ore. However, it is estimated that 25-30 percent of the populated area of Butte is covered with phosphate slag. The report recommended that the phosphate slag not be used in the construction of buildings for human occupancy, Butte road construction or area graveling.

Ambient Air

Concentrations of radon in ambient air at the Hebgen Park Monitoring Station ranged from 0.25 to 3 pCi/liter of air, averaging 0.98 pCi/L. At a station on Hornet Street, ambient air concentrations of radon ranged from 1.47 to 5.86 pCi/L of air, averaging 3.25 pCi/L.

A RPISU was used at the Hornet Street station to monitor outside radon progeny concentrations. The average outside radon progeny concentration for the period February 1982 through January 1983 was 0.0031 WL. The average radon concentration measured at the Hornet Street Station (3.25 pCi/L) will produce a radon progeny concentration of 0.010 WL at an equilibrium of 32 percent.

The outside radon concentrations measured at the Hornet Street Station are higher than normally expected. Worldwide, ambient radon measurements normally vary from less than 0.1 pCi/L to about 1 pCi/L.

Radon in Soil Gas

Efforts to correlate the surface of specific geologic rock types with indoor radon measurements was partially successful. No home investigated that

was built over rhyolite had indoor radon progeny concentrations exceeding 0.02 WL. Radon soil gas measurements in rhyolite were low. Six radon soil gas measurements in rhyolite averaged 80 pCi/L during summer months as compared to an average of 1082 pCi/L for the Butte area as a whole.

Overall soil gas concentrations ranged from less than 100 pCi/L to over 10,000 pCi of radon/L of air. There is a sufficient correlation between radon soil gas measurements and indoor radon concentrations to predict that elevated radon gas in soil may indicate a potential indoor radon problem.

Worldwide radon soil gas concentrations average about 100 pCi/L. Radon soil gas concentrations can be expected to vary from about 50 to 500 pCi/L. Data from about 300 worldwide surveys indicate that only 12 of the areas measured had radon soil gas concentrations averaging above 1000 pCi/L. Butte is one of the 12 areas, with sites ranging from 1082 pCi/L in summer to 1407 pCi/L in winter.

Surface Geology

Radon soil gas measurements in rhyolite were generally less than 100 pCi/L. Rhyolite is not considered a source of Butte's indoor radon problem.

Radon soil gas measurements over aplite intrusions and quartz monzonite appeared to be approximately the same as the Butte average.

The mineralized vein material emits substantially more radon than aplite, quartz monzonite and alluvium material.

Surface expressions of fractures and mineralized veins are believed to be related to the most severely elevated indoor radon concentrations.

Radon soil gas measurements over fractures and over mineralized veins were often five to ten times higher than the average concentrations measured in the

Butte area. Gamma radiation measurements at mineralized veins also are often an order of magnitude higher than measurements of surrounding rocks.

Comments

Ambient air, soils and surface geology all contribute to the indoor radon problem in Butte. It is believed that homes constructed over major fractures or mineralized veins are the most severely affected. Mineralized veins and fractures may act as conduits for transport of radon gas. This theory would also account for the erratic soil gas measurements in fractured areas and areas interlaced with veins.

It is possible that ambient air is a significant source of indoor radon during certain atmospheric conditions in structures having no other substantial source of radon. The study did not provide any information on the specific contribution of abandoned mine lands to the radon gas problem of Butte. But the data would imply that it may be appropriate to study this aspect further.

IX. RECOMMENDATIONS

The air quality/health investigation has identified two major conclusions. First, the Butte community population has a higher than normal rate of lung cancer and respiratory and circulatory system diseases that can be associated with airborne pollutants. Second, dust from the streets of Butte in the abandoned mine land areas contain significant quantities of toxic metals, sulfate and free silica agents that have been implicated in cancer and disease formation when inhaled through the human respiratory system.

The recommendations submitted as a result of this study have been grouped into near-term, intermediate and long-term efforts.

A. Near-Term Efforts

1. A stabilization/reclamation program should be designed and implemented to reduce the amount of material eroded from the dumps and deposited on the city streets from
    a. Ophir Mine
    b. Anselmo Mine
    c. Emma Mine
    d. Original Mine
    e. Mountain Con Mine
    f. Travonia Mine/Star West Dump Area
2. Samples of street dust should be obtained and analyzed at locations related to
    a. Colorado Mine Dump
    b. Buffalo Mine Dump
3. The potential air pollution impact of the Clark Tailings area should be studied in detail.

B. Intermediate Efforts

1. Conduct an expanded street dust sampling and chemical analysis program in the Butte community approximately north of Silver Bow Creek.

2. Conduct a detailed soil sampling program in residential areas and abandoned mine land areas to determine background levels of toxic chemical constituents present.
3. Expand the chemical analysis of total suspended solids collected at local air monitoring stations to include toxic metals, sulfate and free silica.
4. Conduct an ambient air sampling program in residential areas proximate to abandoned mine lands that are contributing to the air pollution of Butte. It is important to identify all constituents in the suspended particulates in order to attempt to understand their potential synergistic effect upon the health of the local population.

C. Long-Term Effects

Conduct an epidemiological study in Butte to

1. Determine if the incidence and causes of mortality and morbility are in any way associated with the neighborhood of primary residence.
2. Conduct a follow-up study of Butte children who are exposed to known or suspected health hazards resulting from environmental air pollution. Progressive changes in health and latent effects should be documented and studied.

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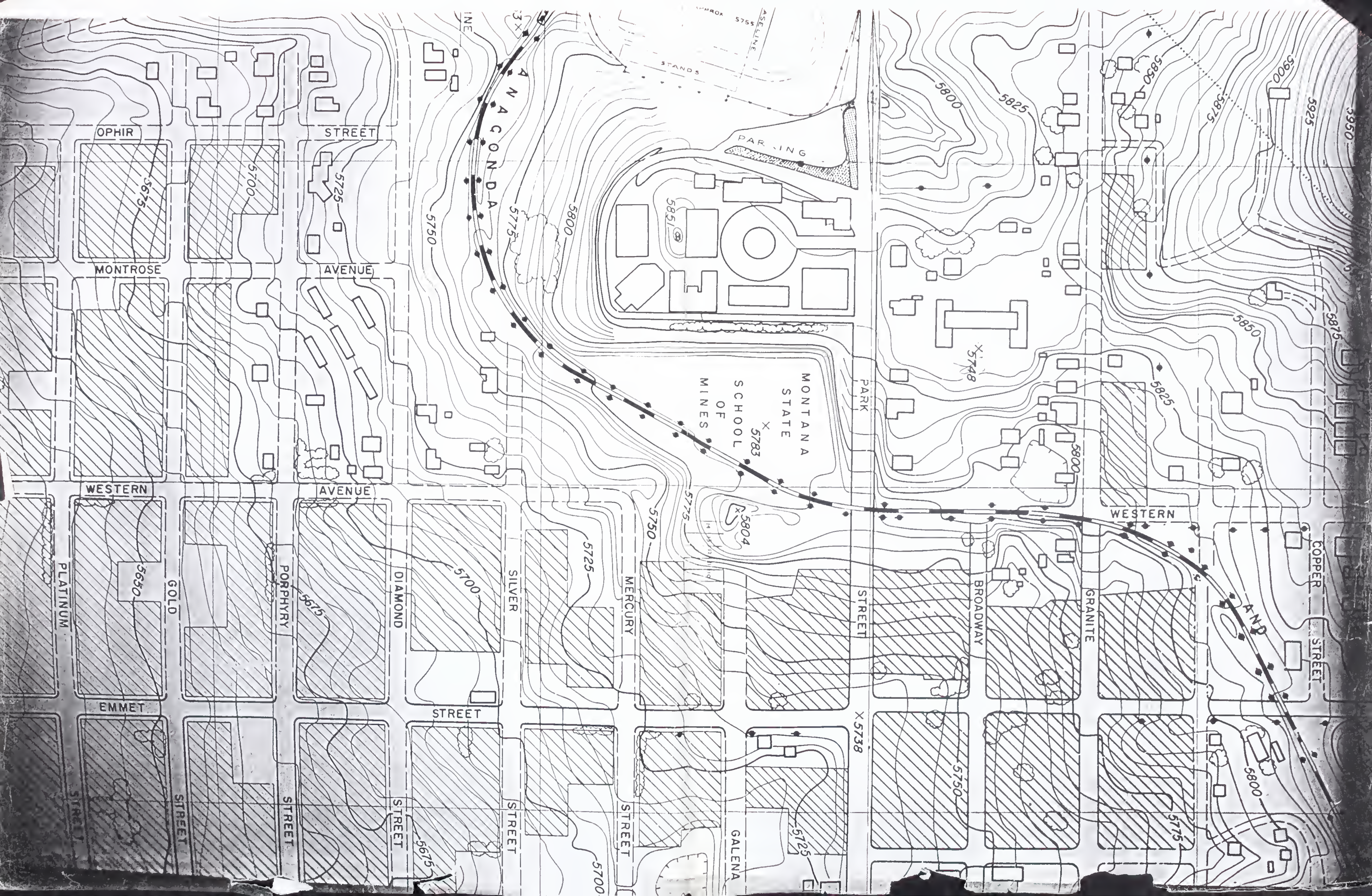
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